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The Agriculture - Public Health Connection

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Dennis Keeney Distinguished Lecture

Leopold Center for Sustainable Agriculture

Iowa State University

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Robert S. Lawrence, MD

Center for a Livable Future

Health of Soil, Plants, Animals, and People

“ whole problem of health, in soil, plant, animal and man is one great subject.”

— Sir Albert Howard, 1939

There Is No Connection between Food and Health …

"There is no connection between food and health. People are fed by a food industry which pays no attention to health and are healed by a health industry that pays no attention to food."

— *Wendell Berry*

Connected to Agriculture?

"We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."

—Aldo Leopold

WHAT DOES THE 2007 U.S. FARM BILL HAVE TO DO WITH PUBLIC HEALTH?

1. Healthfulness of foods promoted
2. Access to healthy food
3. Access to sustainably produced food incl. local
4. Resource depletion, greenhouse gases
5. Conservation-based agriculture
6. Food sovereignty
7. Overly cheap feed grains
8. Informing consumers
9. Alternative energy
10. Rural communities

Need for Public Health Oversight

Who Consumes the World's Food?

- Grain consumption per capita per year
  - U.S.A. ~ 800 kg
  - Italy ~ 400 kg
  - Taiwan ~ 300 kg
  - China ~ 250 kg
  - India ~ 200 kg

Why?

- Meat-based diets consume more resources than plant-based diets
  - ~700 kg grain to produce 100 kg of beef
  - ~400 kg grain to produce 100 kg of pork
  - ~200 kg grain to produce 100 kg of poultry

Walker, P., Rhubart-Berg, P., McKenzie, S., Kelling, K., and Lawrence, R. S. (2005). Public health implications of meat production and consumption. *Public Health Nutrition, 8(4),* 348–356.

Diet and Health

Actual and Projected Meat Consumption (million metric tons)			
	1983	1993	2020
China	16	38	85
India	3	4	8
Developed countries	88	97	115
Poor countries	*50*	*88*	*188*
World	*139*	*184*	*303*

Source: International Food Policy Research Institute. (1999). *Livestock to 2020: The next food revolution*.

Global Meat Demand Doubling in 30 Years

- Since 1961 U.S. per capita meat consumption has increased by 70% from 141 pounds to 223 pounds (100 kg)
- Average for industrialized countries is 77 kg/person
  - For non-industrialized countries—27 kg/person
- Global demand for meat will double from the 1990s to 2020

Pesticide Use and Pollution

- Pesticide residues from industrial agriculture enter our bodies through food, water, and air, and they raise risks for certain cancers as well as reproductive and endocrine system disorders
  - 1 billion pounds of pesticide/year in U.S.[1]
    - 35% of food contaminated with pesticide
  - 5 billion pounds of pesticide/yr worldwide[2]
    - 98% of food in India is contaminated

1,2. http://www.epa.gov/oppbead1/pestsales/01pestsales/usage2001.html.

What Is Food Security?

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life."

— *Food and Agriculture Organization of the UN (FAO),1996*

Famine and Hunger

- Hunger and famines have plagued mankind for millennia and have been concerns of human societies for centuries
- According to FAO, almost 20 million infants per year are born with low birth weights

Bhutan

Photo source: Mattioli, F. WFP Photo. http://www.fao.org/NEWS/FOTOFILE/PH9701-e.htm

Food As a Human Right

- Food is necessary for life and everyone should have access to adequate food
- Universal Declaration of Human Rights

  Article 25

  "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family including food, clothing, housing, and medical care and necessary social services …"

http://www.un.org/Overview/rights.html

World Food Production

- Total world grain production continues to grow
- A record crop in 2004 of 2,049 billion tons
- Providing 322 kg of grain per person per year, or about 2,700 calories per person per day worldwide
- This exceeds the 2,350 calorie minimum per day set by FAO
- Adequate food is available to feed all the world's people

Sources: (2005). World Watch Vital Signs, pages 22–23; Children First. Retrieved from http://www.childrenfirst.org.za/shownews?mode=content&id=17376&refto=2635

Food Security and Methods of Production

- The current (2001) definition of food security includes methods of production
  - "A world where every person has access to sufficient food to sustain a healthy and productive life, where malnutrition is absent, and ***where food originates from efficient, effective, and low-cost food systems that are compatible with sustainable use of natural resources***"

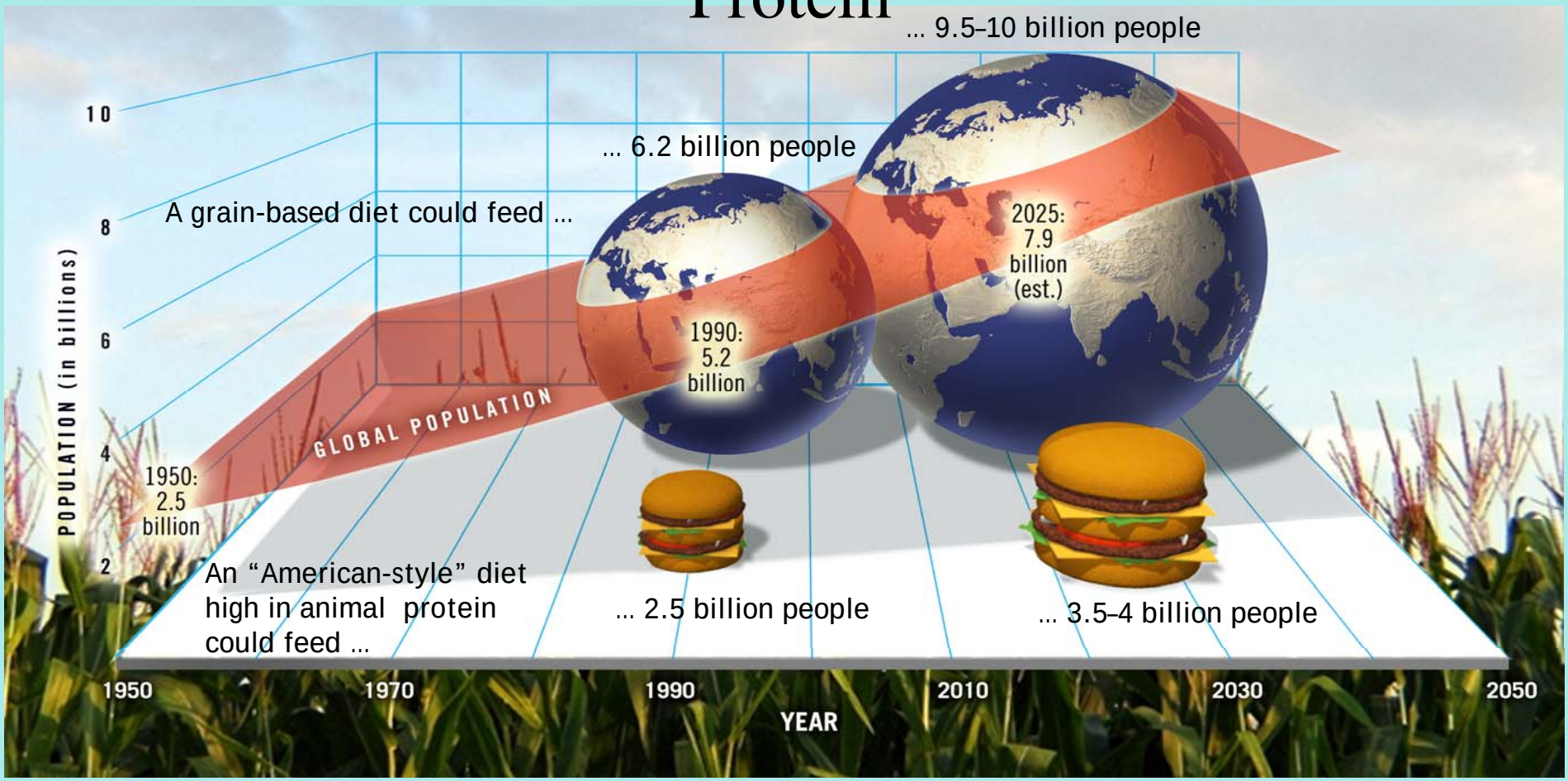
    — Vision for 2020—Sustainable Food Security for All by 2020

    September 4–6, 2001, Bonn

    http://www.ifpri.org/2020conference/

Source: International Food Policy Research Institute.

Plant-Based Diets vs. Diets with Animal Protein



Height of each world = Number of people that could be fed on a plant-based diet in 1990 and 2020

Height of each hamburger = Number of people that could be fed on a diet with 30% of calories from animal protein

Height of red line = actual world population to 2004, then estimated to 2050

Food Production: Nutritional Impacts

Obesity Epidemic

OBESITY EPIDEMIC

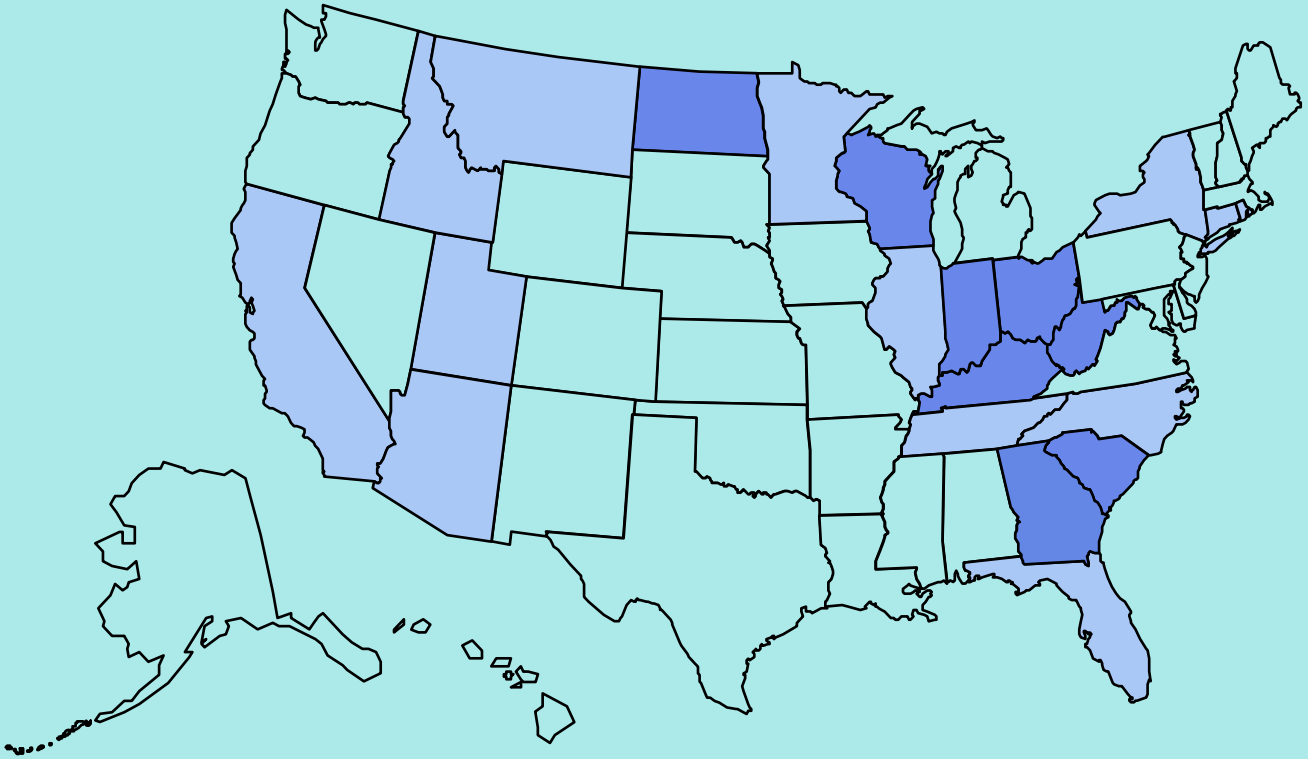
- High rates
  - 17% children/adolescents overweight
  - 32% adults obese
- Disparities
  - African American adults 45% obese
  - Mexican American adults 37% obese
- High impact
  - Over 300,000 deaths/yr
  - Heart disease, diabetes, cancer, stroke, stigma, etc.
  - $117 billion/year (treatment, direct, indirect costs)

Ogden et al 2006, DHHS 2001

OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1985

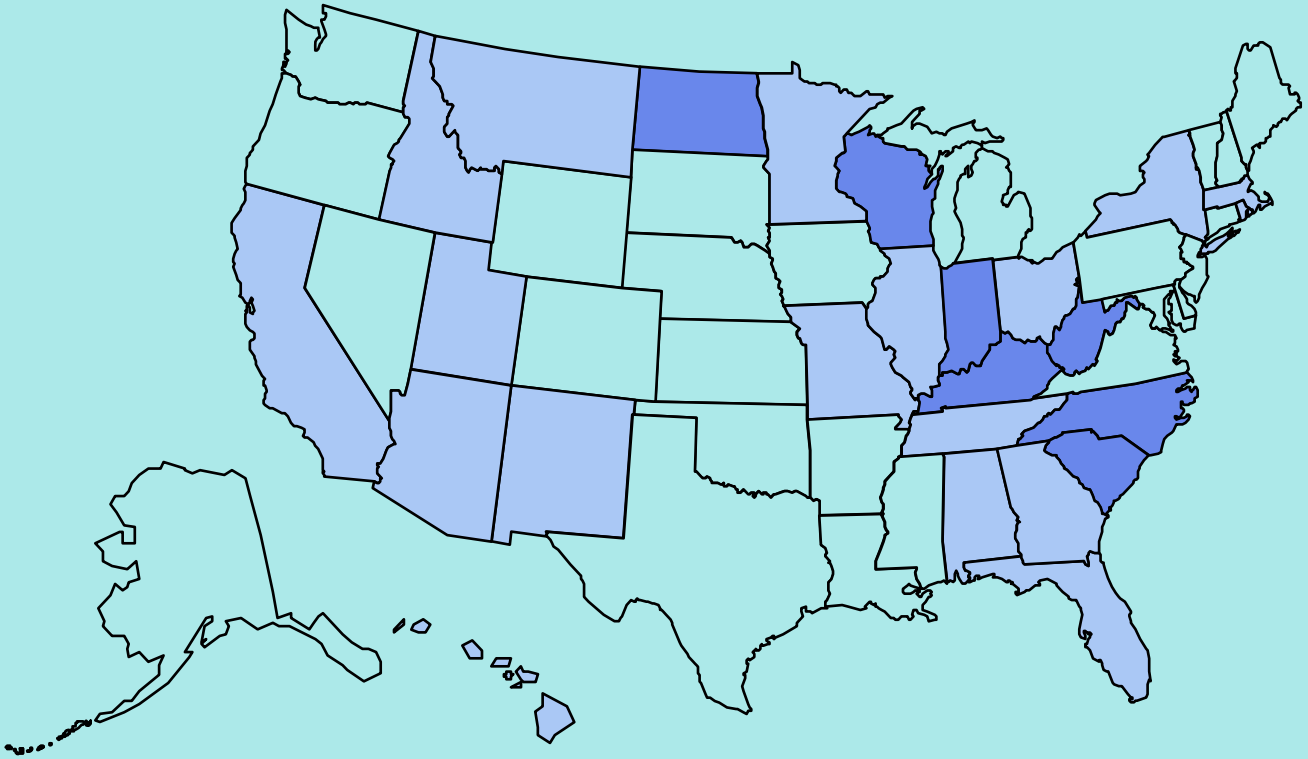
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1986

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1987

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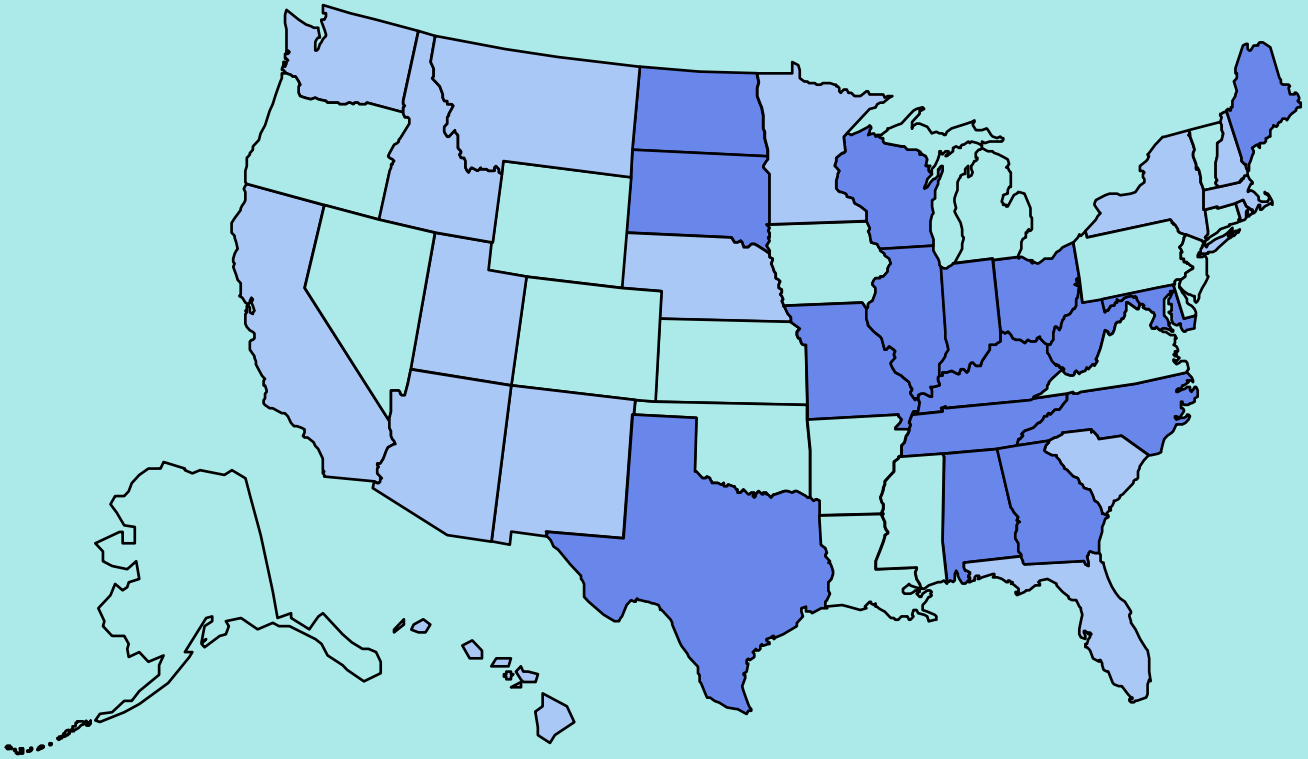
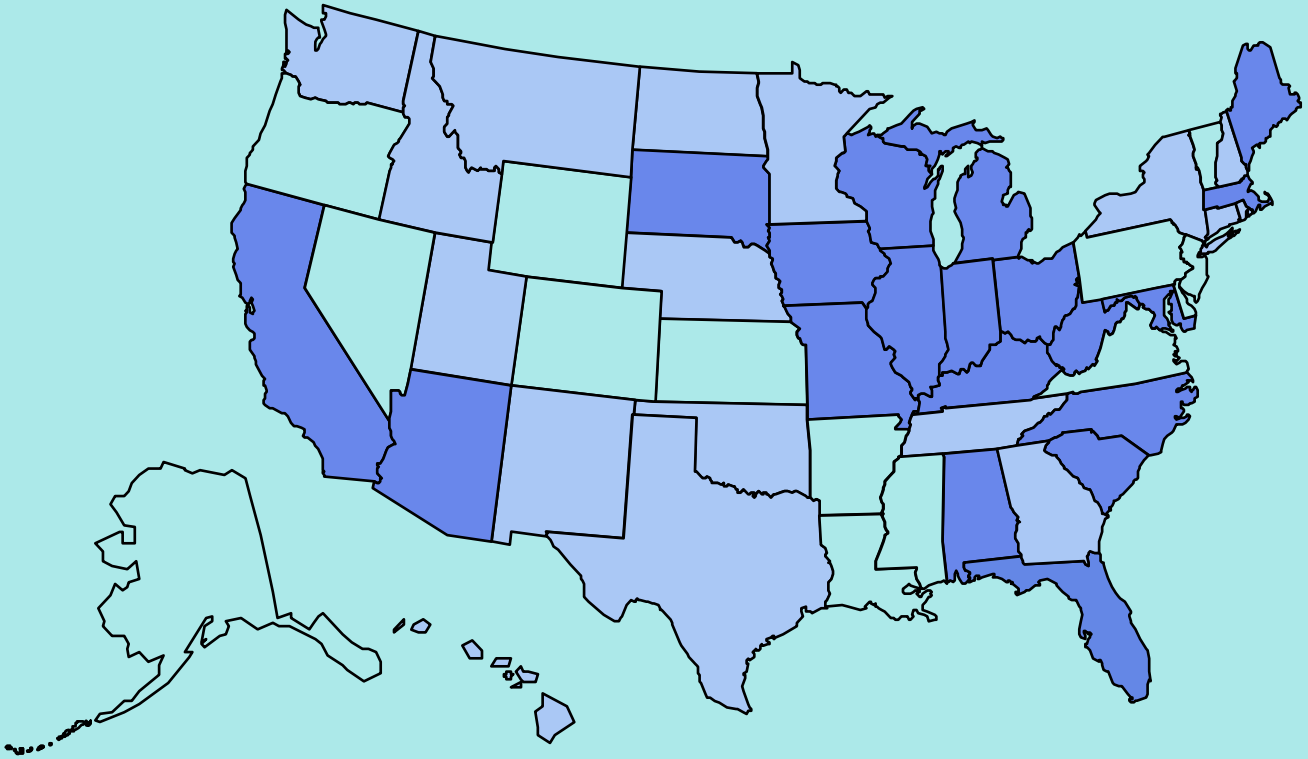


No Data | <10% | 10%–14%

OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1988

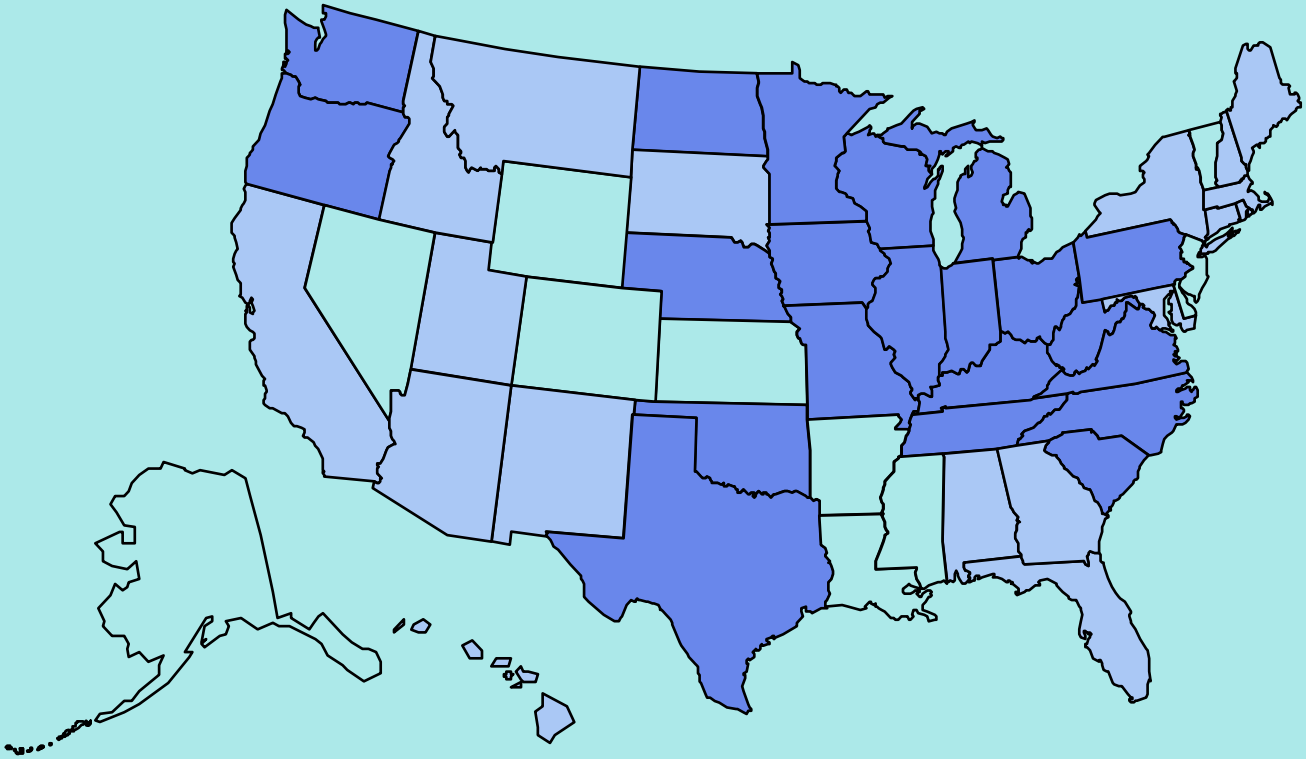
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1989

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1990

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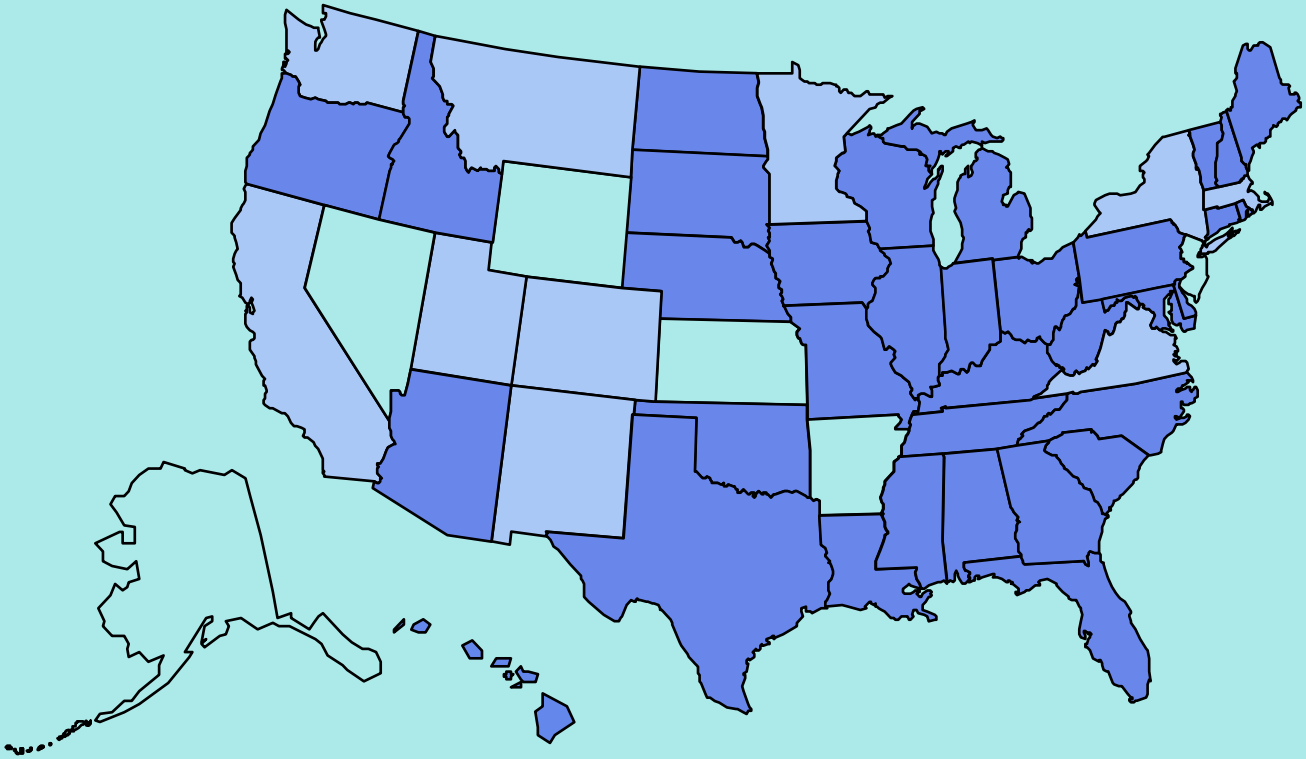
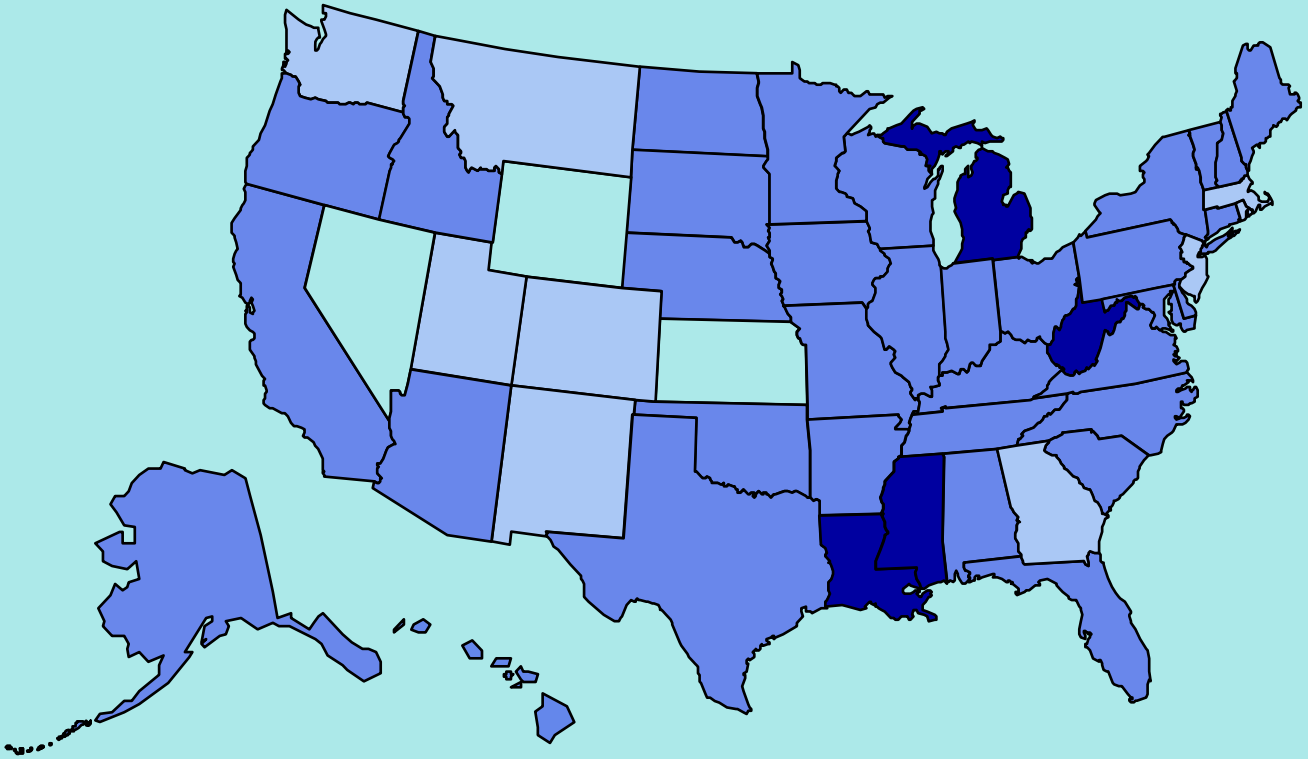


OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1991

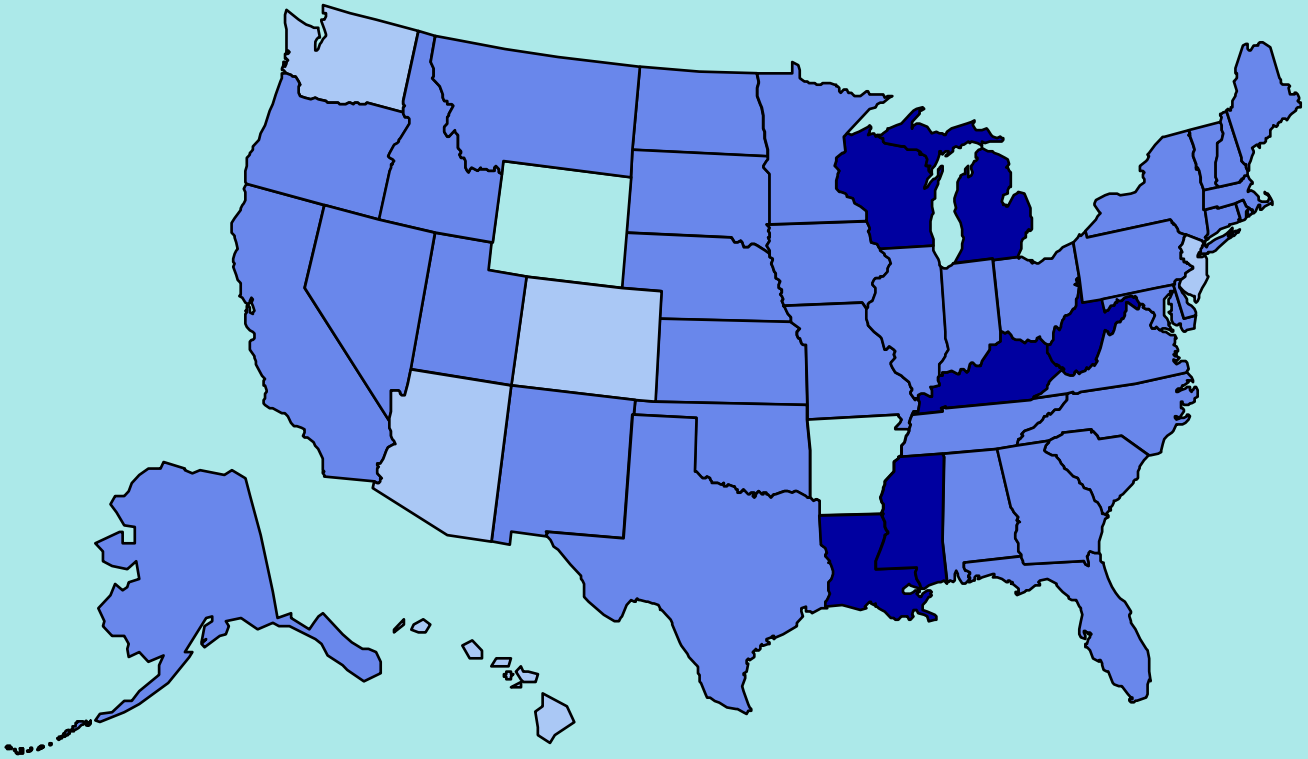
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1992

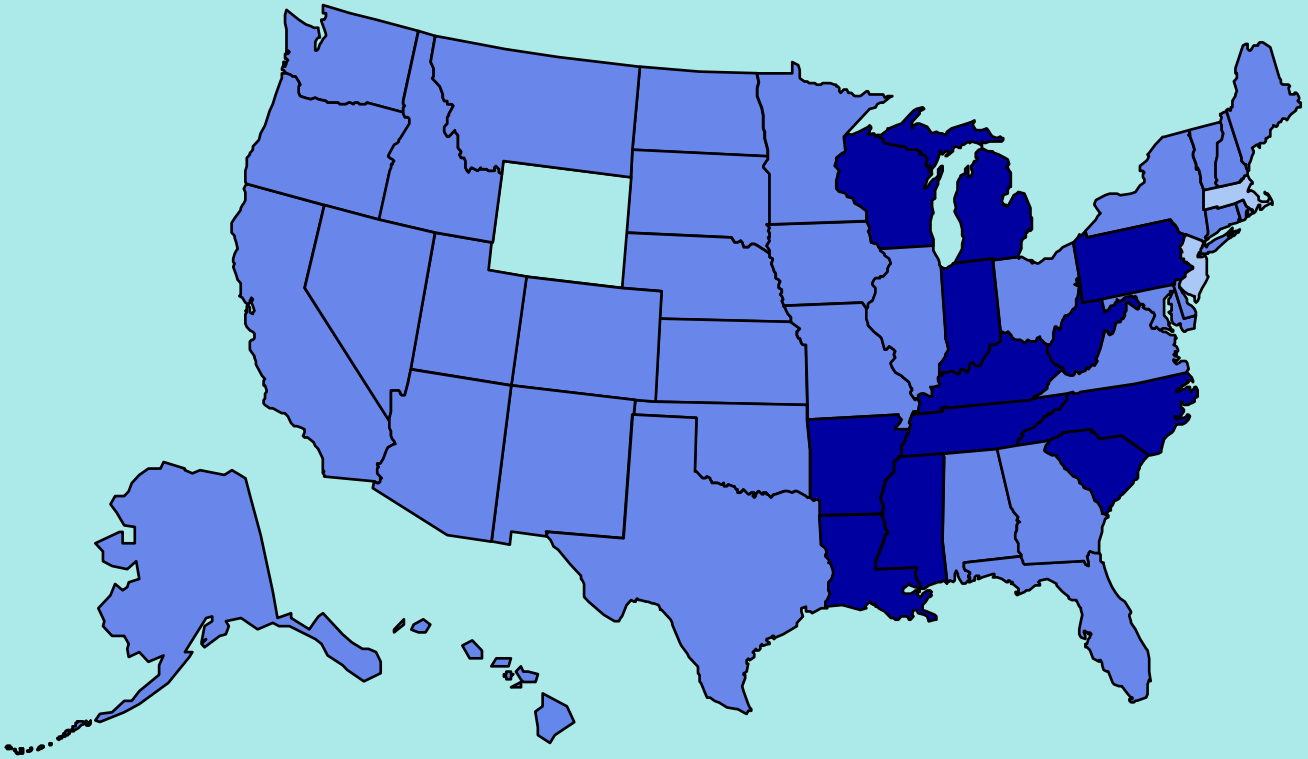
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1993

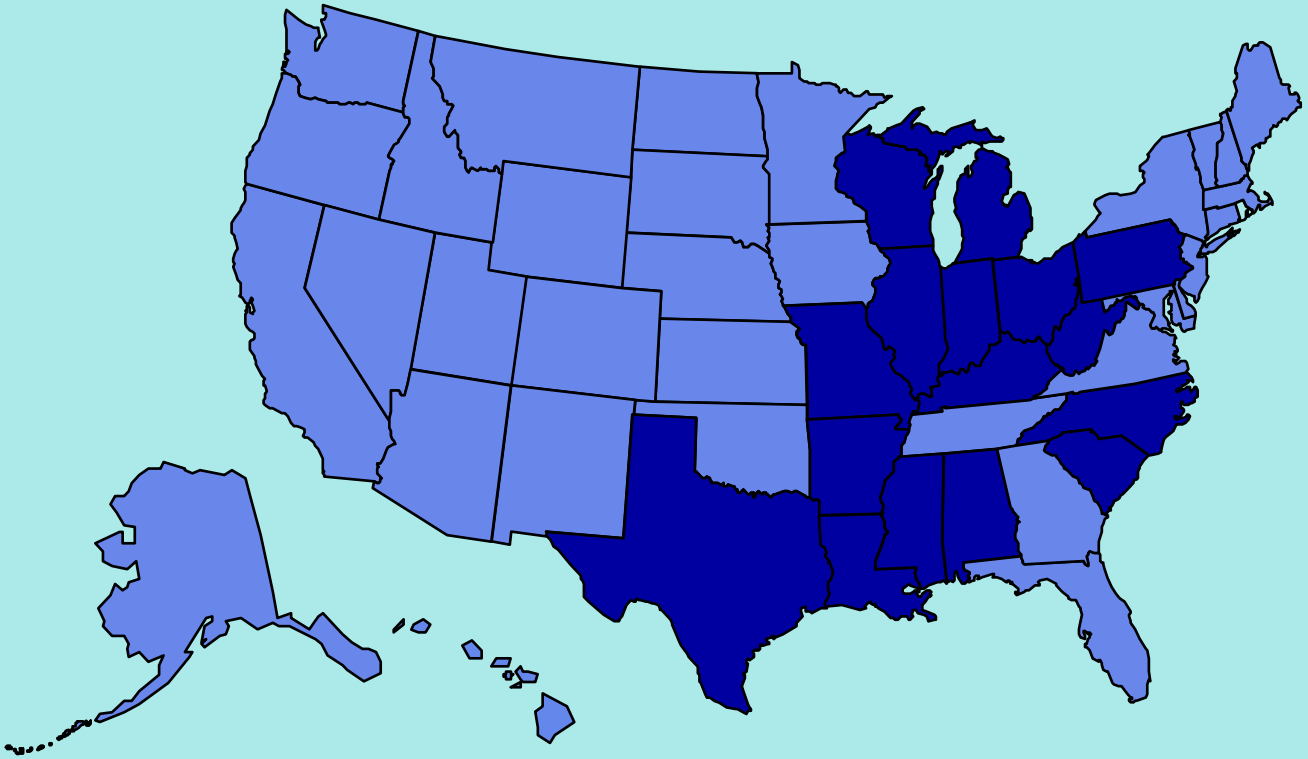
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1994

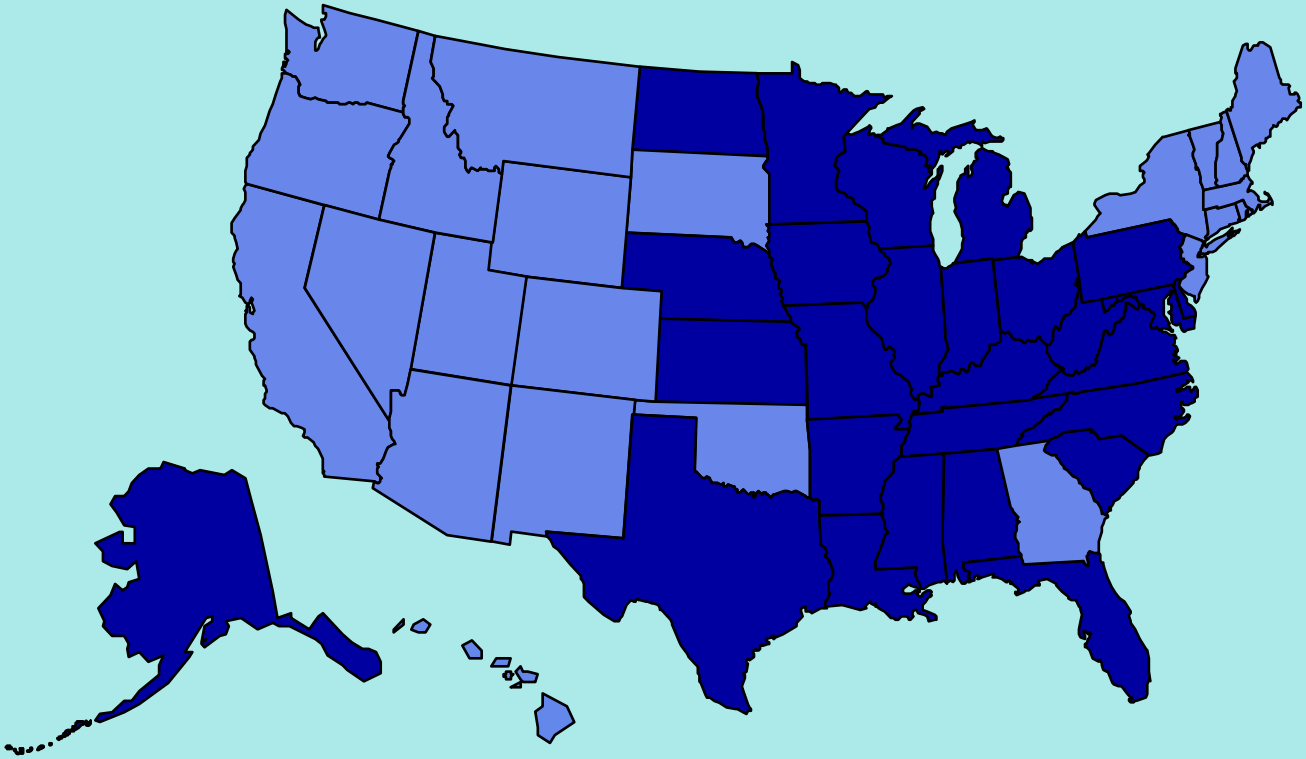
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1995

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1996

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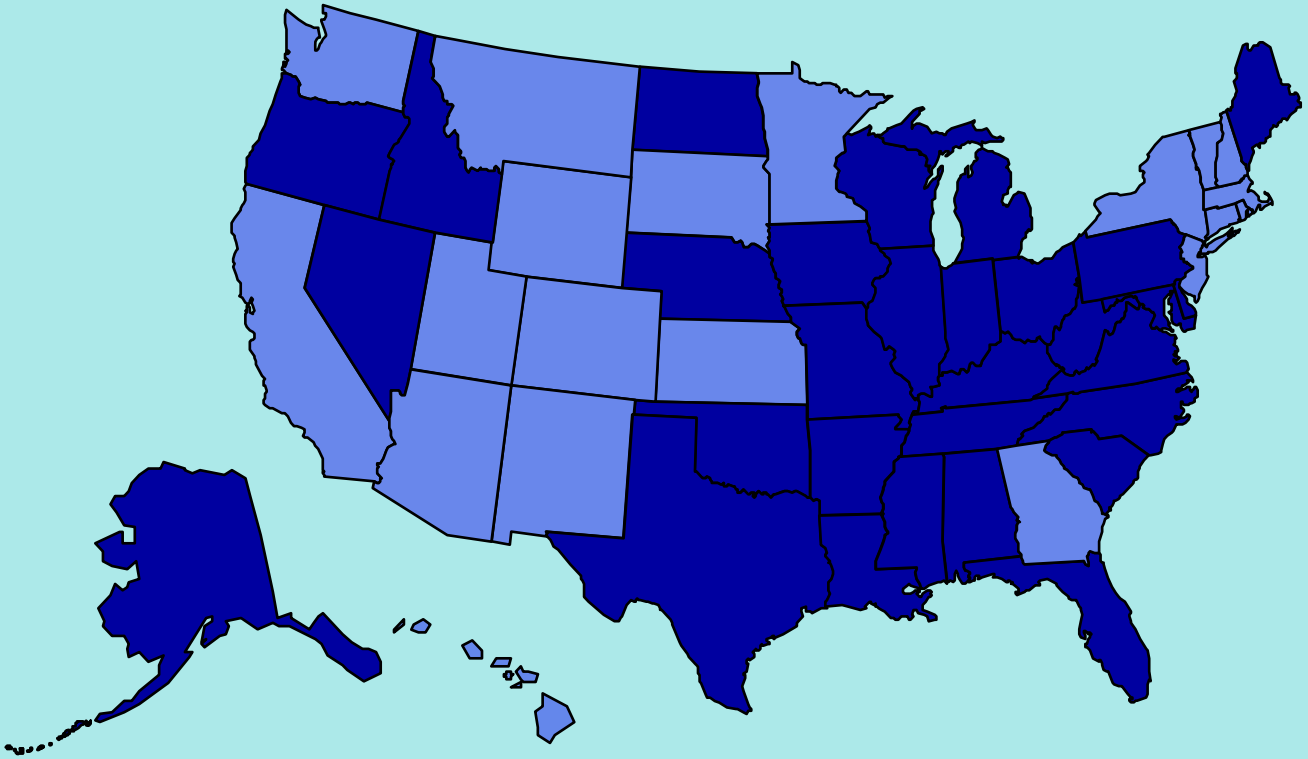
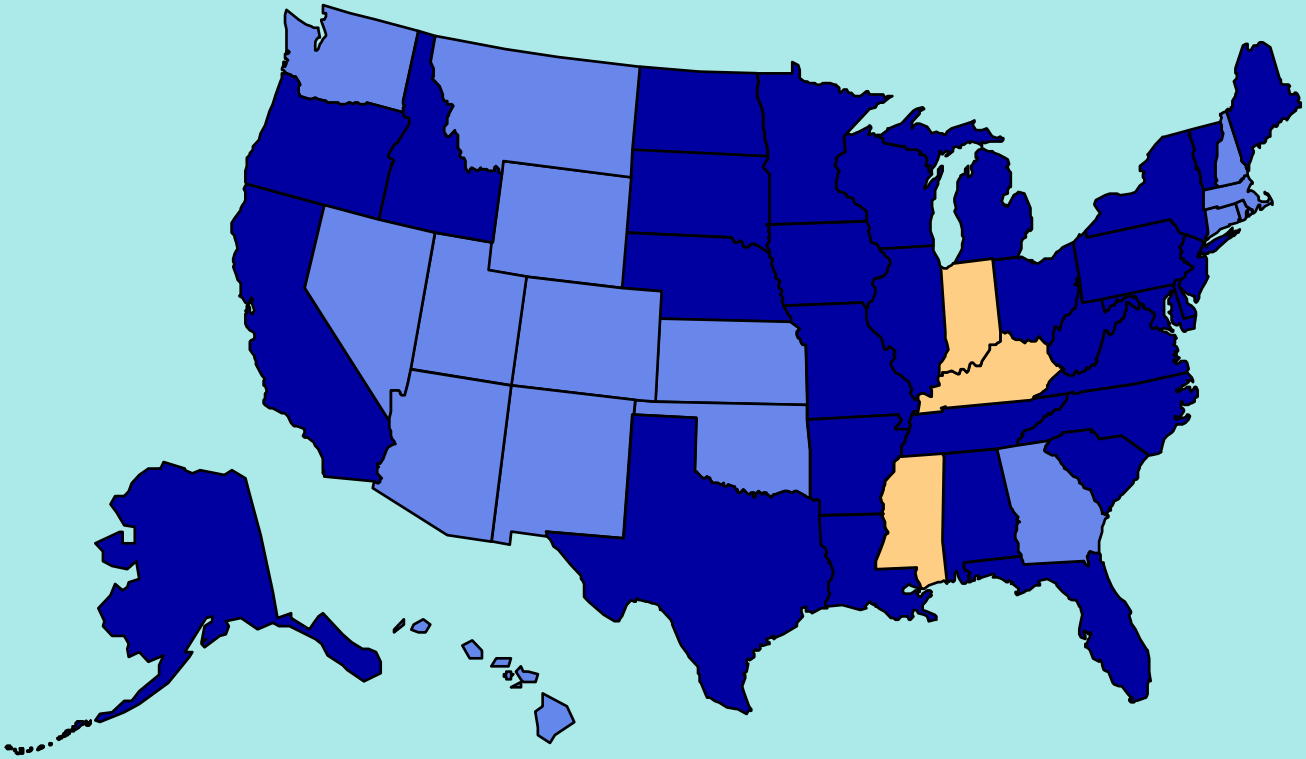


OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1997

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1998

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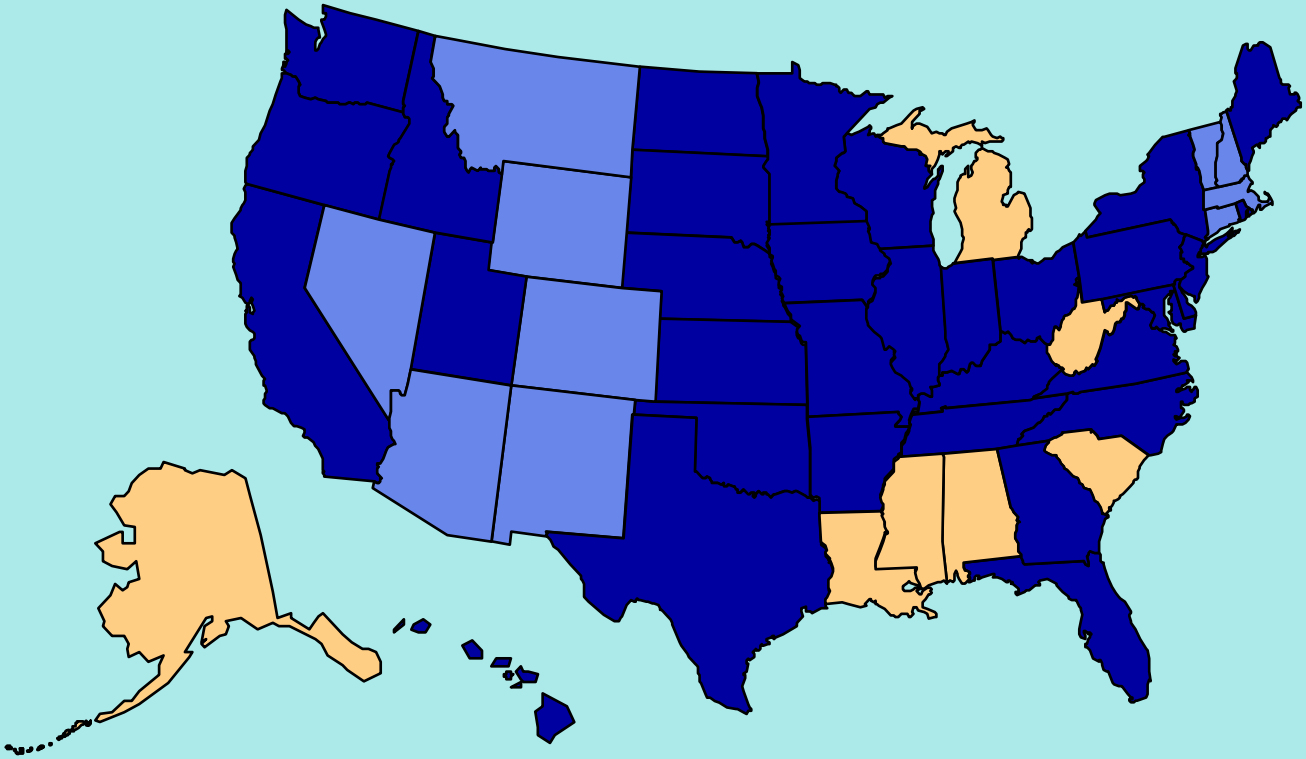

OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 1999

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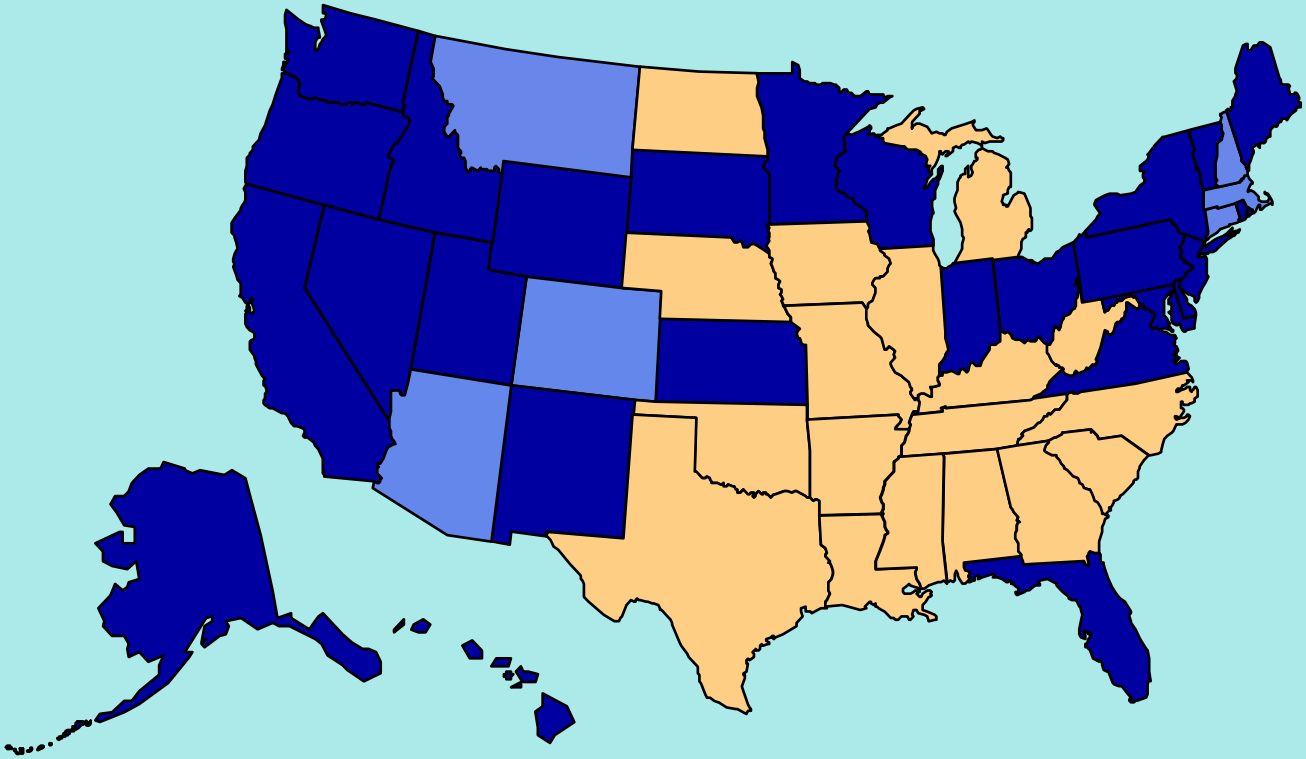
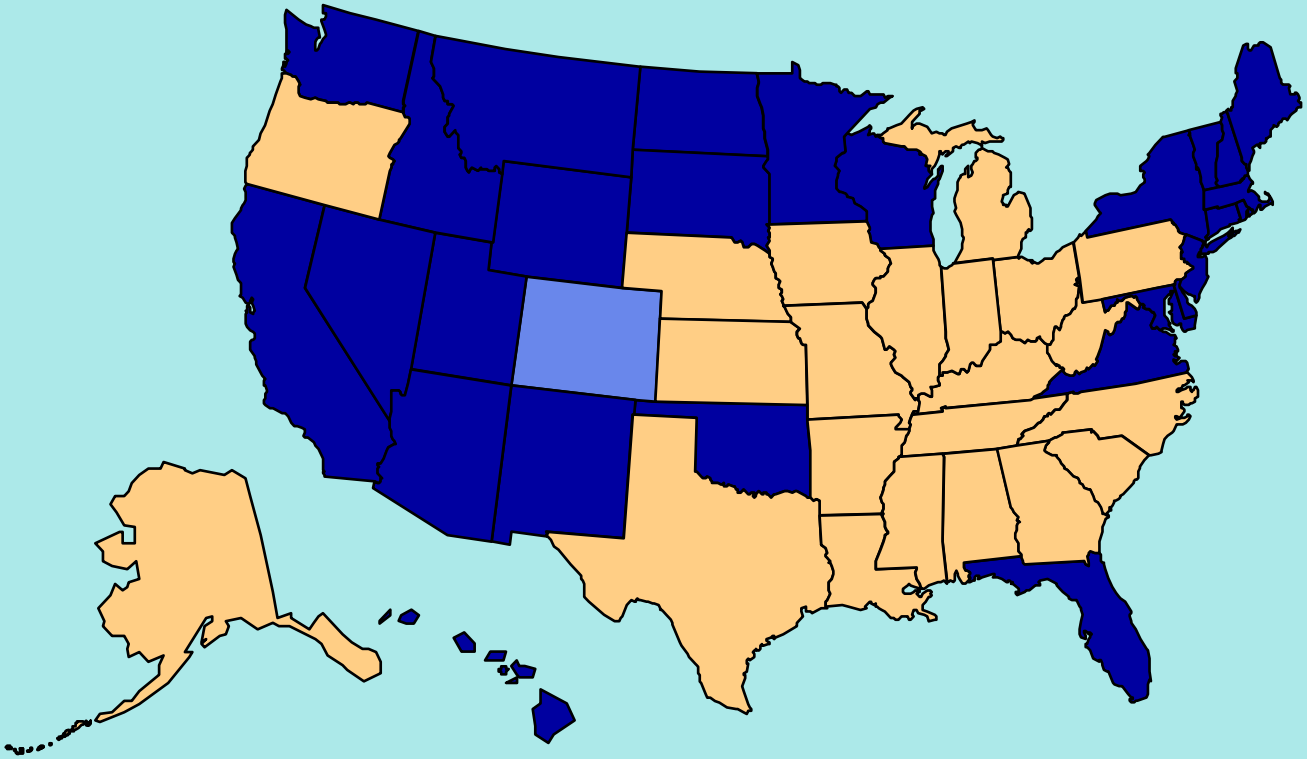


OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 2000

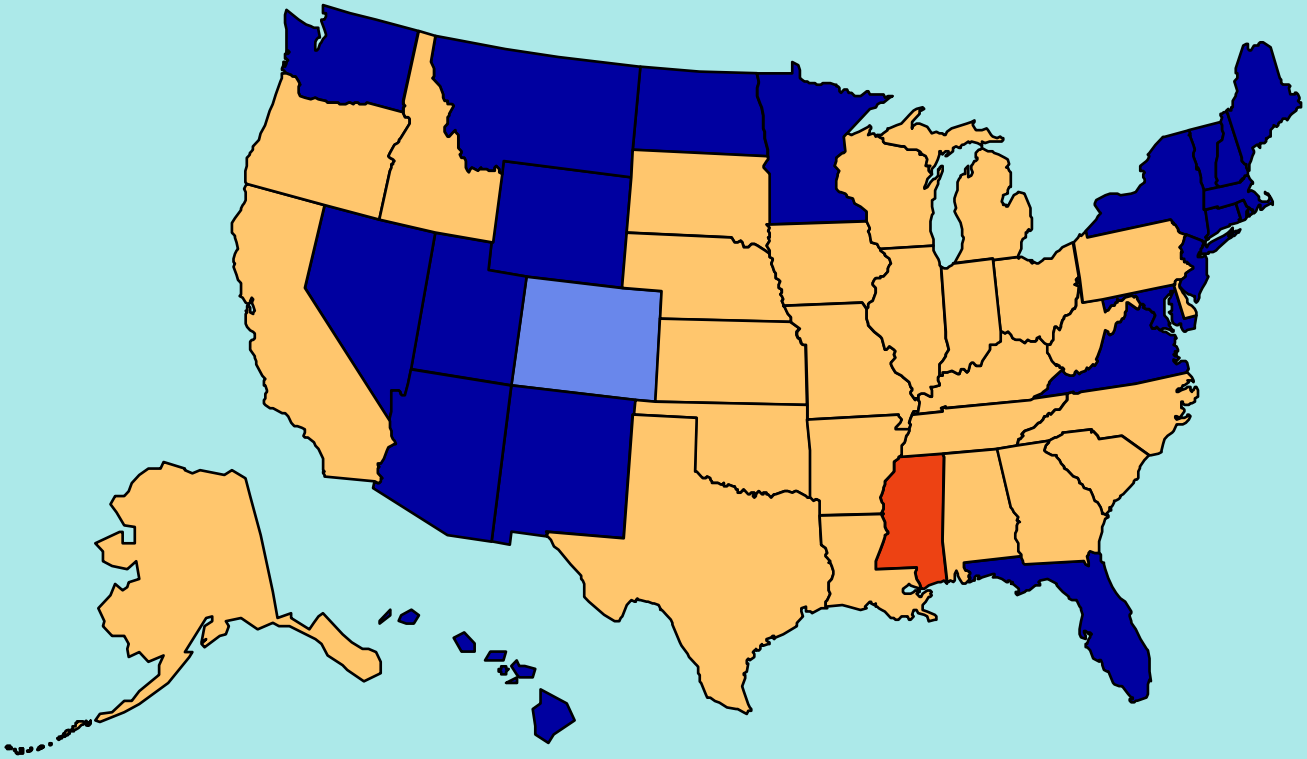
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)



OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 2001

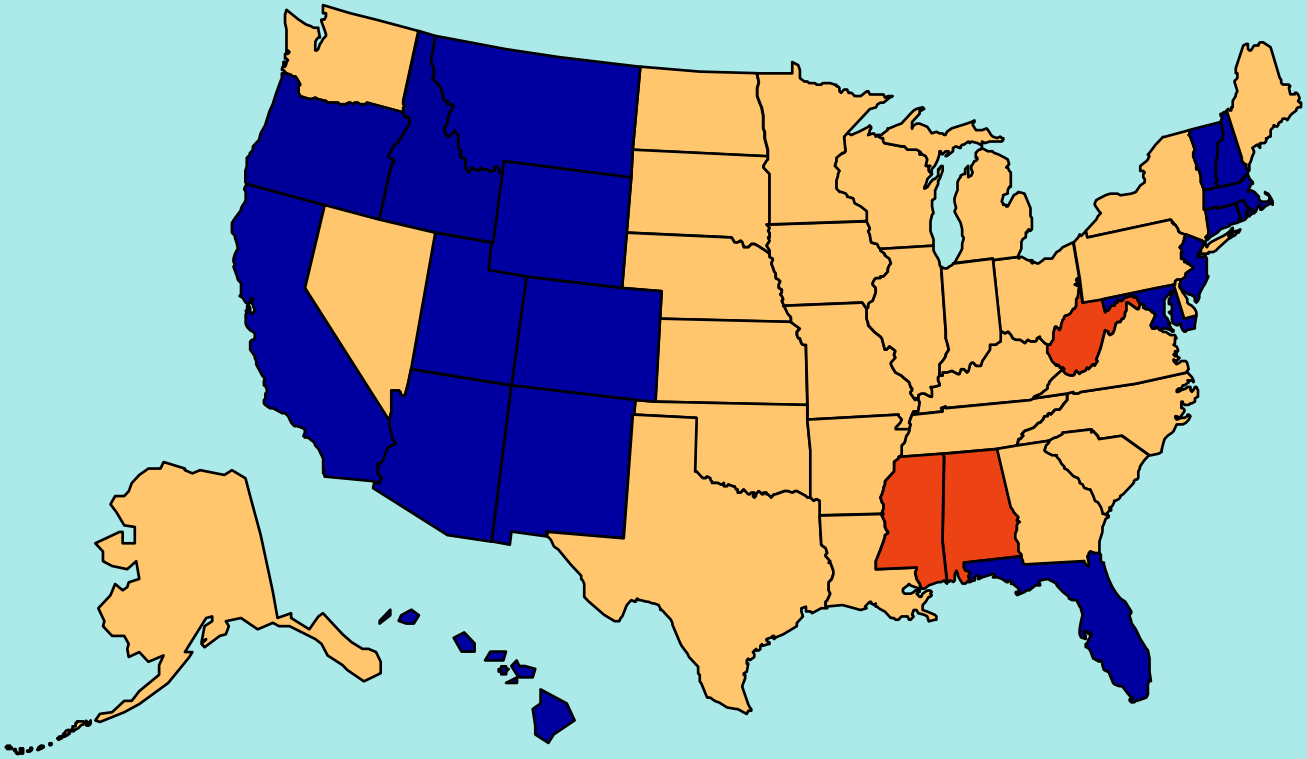
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)

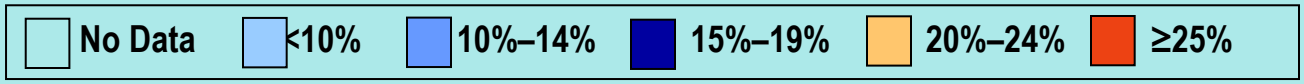


OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 2002

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)

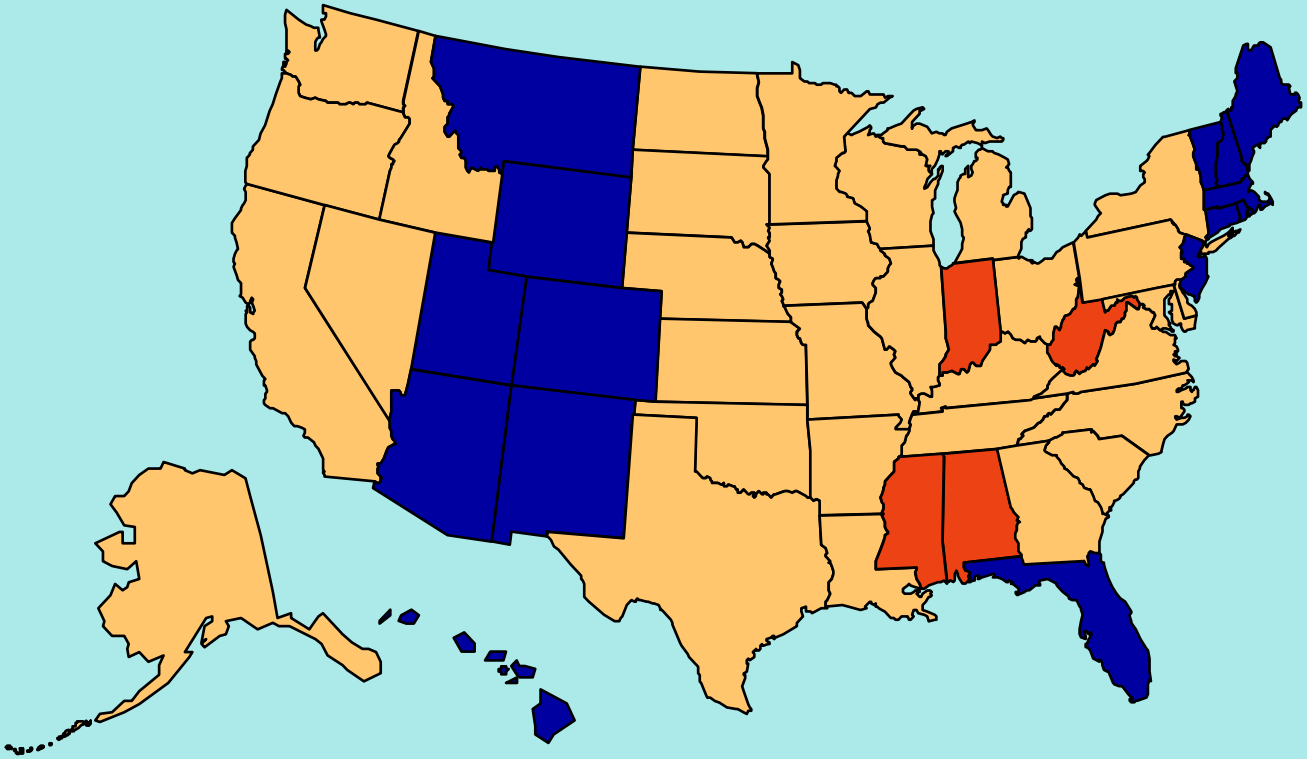




OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 2003

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)

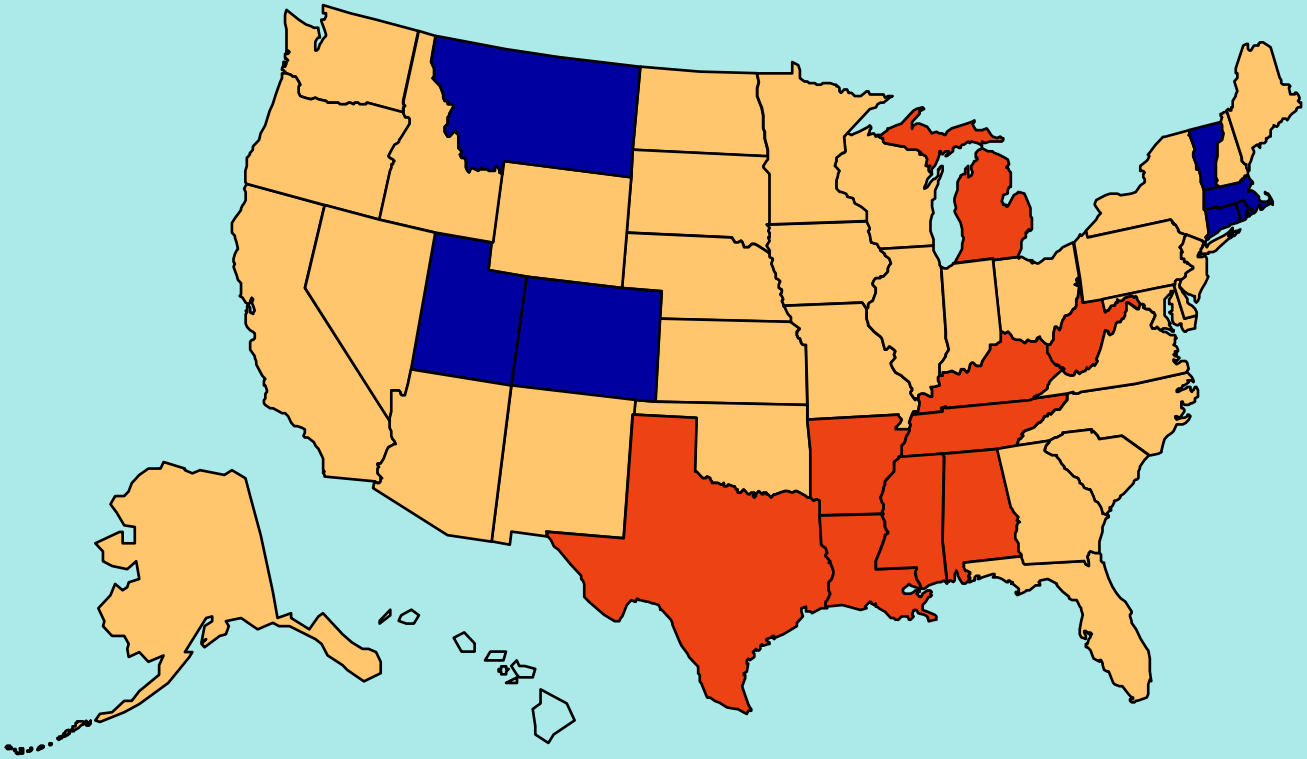


No Data | <10% | 10%–14% | 15%–19% | 20%–24% | ≥25%

OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 2004

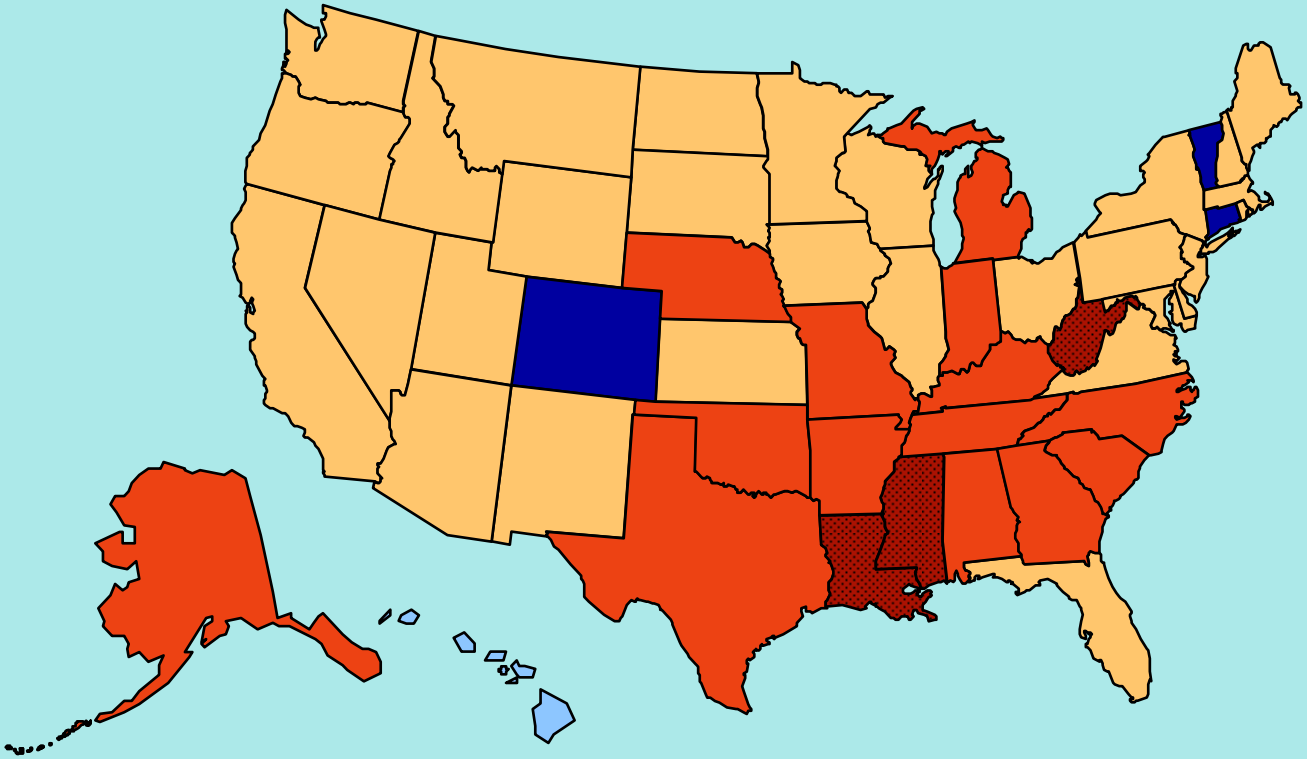
(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” person)

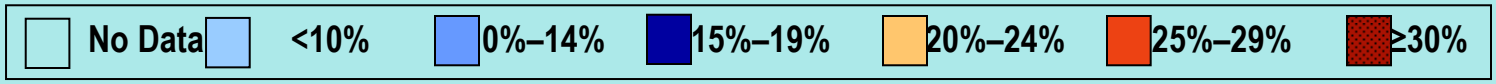


OBESITY TRENDS* AMONG U.S. ADULTS

BRFSS, 2005

(*BMI ≥30, or ~ 30 lbs overweight for 5' 4" person)





What Kind of Food Should We Eat?

- Which is better to eat?
  - Organic grapes transported thousands of miles from Chile,
  - Conventional grapes from California that have been grown using pesticides, or
  - In-season apples grown in the next town
- The food system is very complex and there is no simple, single answer
- We cannot get there all at once, but must go step by step

What Kind of Food Should We Eat?

- A good starting point is the principle of “harm reduction”
- The most important action is to begin to make informed choices about what we eat—and to think about the connections and consequences of what we do and weigh the necessities and tradeoffs
- Good nutrition and a variety of fruits and vegetables are important, but does that mean we need to eat asparagus all year long?

Changing Our Current Food System

- What can public health professionals do individually and collectively?
  - Make conscious food choice decisions
  - Support sustainable agriculture
  - Support local food security efforts
  - Link food production and food security to public health through research and scholarship

*Note: Brower, M., and Leon, W. (1999). The Consumer's Guide to Effective Environmental Choices: Practical Advice from the Union of Concerned Scientists. Three Rivers Press.

Achievements, with Costs

- Environmental, public health, economic, and social concerns
- Reliance on inputs exacts a heavy cost in pollution and environmental degradation

"Our society and the natural environment bear the cost of these unintended consequences in the form of environmental and public health impacts."

—Keeney and Kemp, 2003

Externalities

- Not included in retail price or in analyses of productivity
- Externalities include
  - Depletion of resources—e.g., fossil fuel, water, soil, and biodiversity
  - Pollution of resources by the products of fuel combustion, pesticides and fertilizers
  - Economic, social and health costs to communities—e.g., lost property values, lost QALYs
- External costs seldom accounted for in the food's price

Other Health Impacts of Food Production Methods

- Environment
- Water
- Air
- Chemicals, hormones, endocrine disrupters, pesticide residues
- Antibiotics and Ab-resistant bacteria

Water Use

- Approximately two-thirds of water use worldwide is devoted to irrigation
- Worldwide, aquifers being depleted for irrigation faster than they can be replenished (e.g., Ogallala Aquifer, the northern plain of China, etc.)
- Direct relationship between the availability of water and the world's ability to meet the nutrition requirements of the population (Stockholm 2004 International Water Institute)

Use of Chemicals

- Heavy reliance on chemical fertilizers, pesticides, and herbicides
- 137 million metric tons of chemical fertilizers used worldwide in 1998 (U.S. agriculture—20 million tons)
- Crops absorb only one-third to one-half of the nitrogen applied to farmland (Tilman)

Use of Chemicals (Continued)

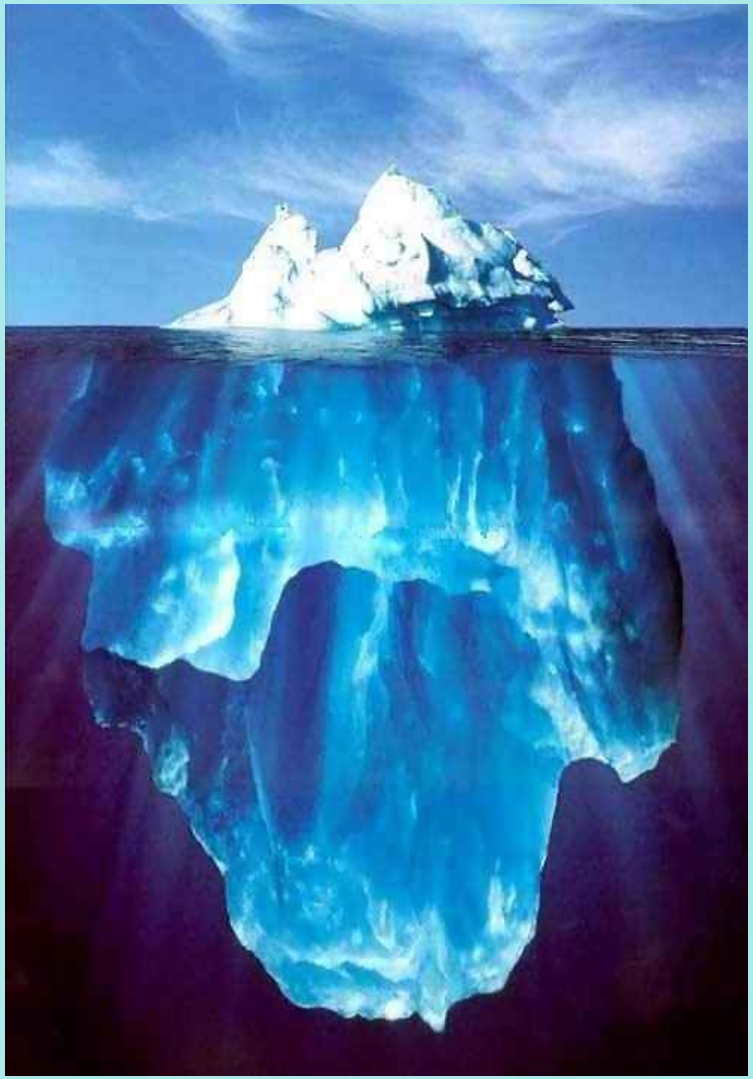
- Over 1,600 chemicals used in the manufacture of pesticide —most have not been tested
- Worldwide, *3 million tons* of pesticides per year
- Human health
  - Poisonings; long-term effects on the immune, reproductive, and nervous systems; increased cancer risk

Produce Contamination and Human Illness

- 76 million cases of foodborne illness in the U.S. per year (Mead et al., 1999)
- Foodborne illness associated with produce is increasing over time

Epidemiology: Why Don't We Know More?

- Reported antimicrobial-resistant (AMR) infections are the tip of the iceberg
- The U.S. National Antimicrobial Resistance Monitoring System (NARMS), etc., assume hospital route, do not fully explore other pathways



FDA-Approved Antimicrobials

FDA-approved antimicrobials for growth promotion and prophylaxis in poultry

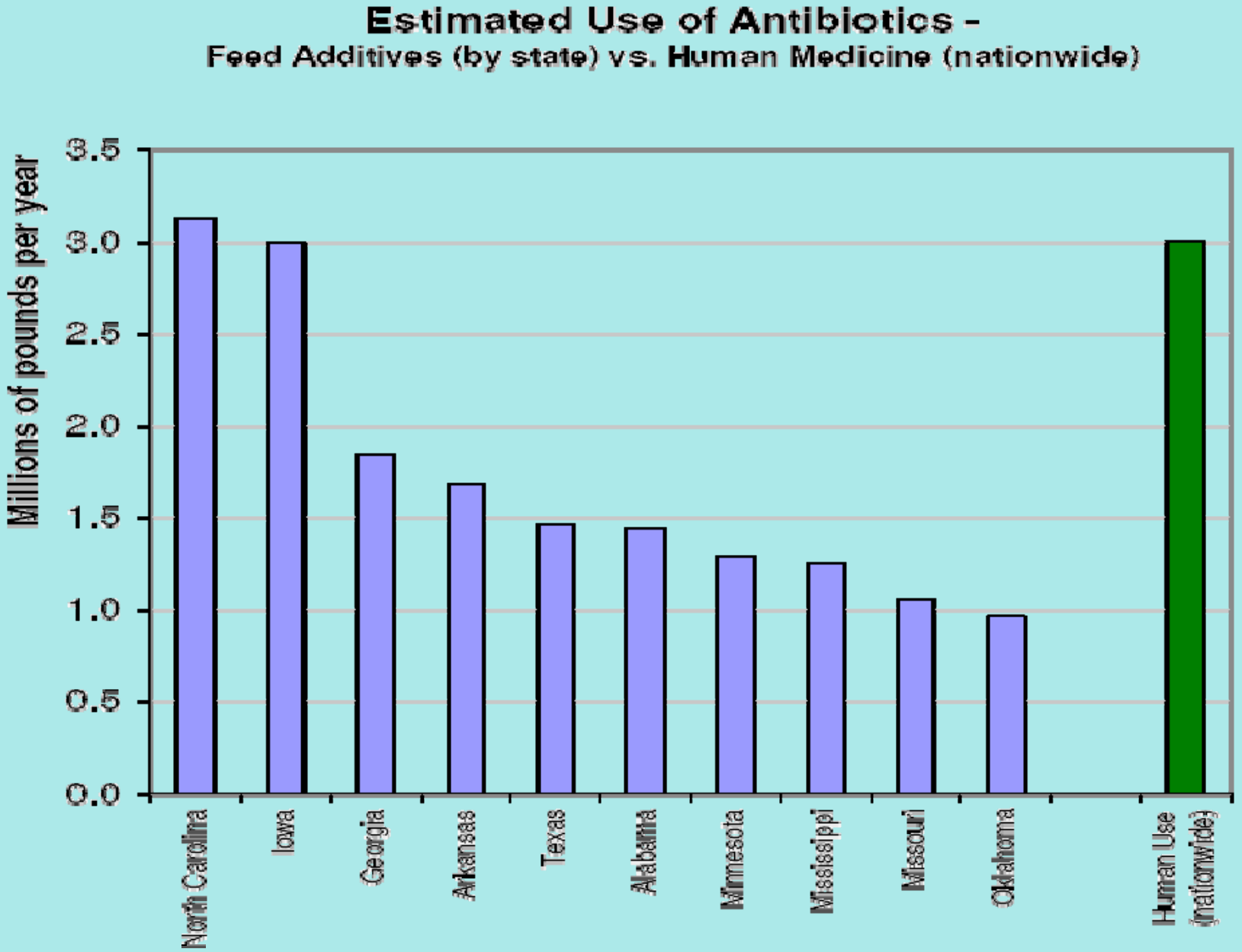
- Bacitracin
- Bambermycin
- Carbadox
- Roxarsone, arsinilic acid
- Chlortetracycline
- Enrofloxacin
- Erythromycin
- Laidlomycin
- Lasalocin
- Lincomycin
- Monensin
- Oxytetracycline
- Penicillin
- Tiamulin
- Tylosin
- Virginiamycin

Source: CDC.

Antibiotic Use in U.S. Food Animal Production

- Antibiotic use in food animal production—United States, 2002
  - Growth Promotion
    - 3.1 million lbs/yr (AHI)
    - 27.6 million lbs/yr (UCS)
  - "Prophylaxis" and disease treatment
    - 14.7 million lbs/yr (AHI)
    - 2.0 million lbs/yr (UCS)
  - ***Compared to human uses***
    - 32.3 million lbs/yr (AHI)
    - 4.5 million/lbs/yr (UCS)

Antibiotic Use: Feed Additives vs. Human Medicine



Conditions Promoting Resistance in Agriculture

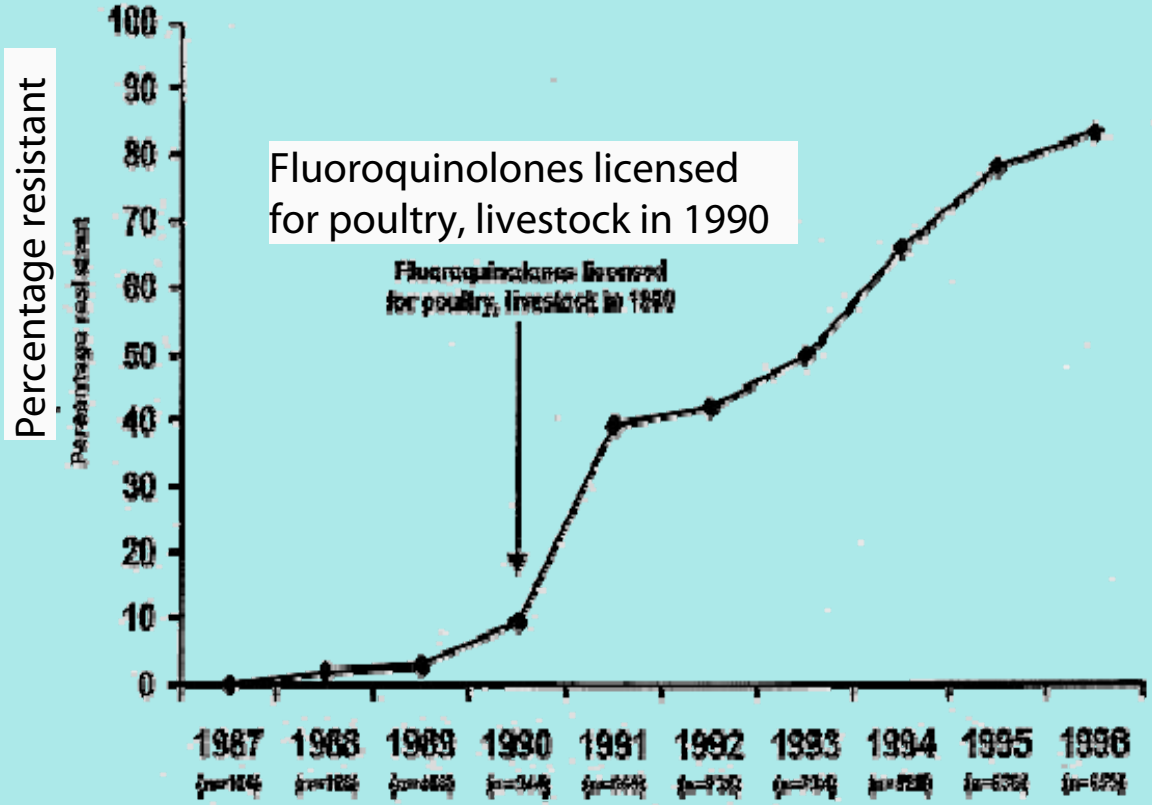
A) Failure of infection control
- Crowding
- Often sub-optimal hygiene

B) Exposure to antibiotics
- Widespread
- Prolonged
- Sub-lethal doses
- Often little dose control

C) Stress reaction
- Increases bacterial shedding

Quinolone-Resistance

- Quinolone-resistance in human isolates of C. jejuni/coli in Spain



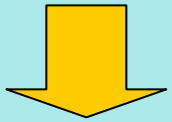
Source: Smith. (2000). Campylobacter. ASM Press.

Outbreaks and Cases of Gastrointestinal Illness Associated with Water Contaminated by Animal Waste

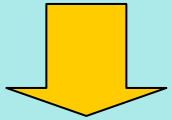
Location	Pathogen	Impact	Suspected Source
Walkerton, Canada	*E. coli* O157:H7 and *Campylobacter*	6 deaths, 2,300 cases	Runoff from farm fields entering water supply
Washington Co., NY	*E. coli* O157:H7 and *Campylobacter*	2 deaths, 700 cases	Runoff fromfairgrounds
Carrollton, GA	*Cryptosporidium Parvum*	13,000 cases	Manure runoff
Swindon and Oxfordshire, UK	*Cryptosporidium Parvum*	516 cases	Runoff from farm fields
Bradford, UK	*Cryptosporidium Parvum*	125 cases	Runoff from farm fields
Swaziland	*E. coli* O157	40,912 cases	Runoff from livestock entering water supply

Effect of Antibiotic Use in Livestock on Human Health

Animals are given antibiotics in their feed throughout their life



Antibiotic resistant bacteria in the gut



Antibiotic resistant bacteria in waste ends up on the meat and in the environment

Human exposure to antibiotic resistant bacteria

Community Health Effects Associated with Swine CAFOs

- Higher rates of respiratory problems, nausea, diarrhea, headaches, and plugged ears
- Higher rates of eye, nose, and throat irritation
- Significantly more episodes of depression, anxiety, anger, fatigue, and confusion among neighbors of swine CAFOs

Schiffman et al. (1995). *Brain Research Bulletin.*

Thu. (2002). *Journal of Agricultural Safety and Health.*

Wing and Wolf. (2000). *Environmental Health Perspectives.*

Results: Air Sampling inside a Maryland Swine CAFO

- Mean concentration of airborne bacteria was 10 colony-forming units (CFUs)/m
- 137 presumptive *Enterococcus* spp.
- Other bacterial species also were identified

Results: Air Sampling

- Regardless of bacterial species, 98% of all isolates were multi-drug resistant, expressing high-level resistance to at least two antibiotics
- ***None of the isolates were resistant to vancomycin, an antibiotic that has never been approved for use in the U.S.***

Results: Air Sampling

Phenotypes of antibiotic resistance among airborne bacteria collected from a swine CAFO

Bacteria	Antibiotic resistance pattern	No. of isolates (%)
Enterococcus		
E. dispar (*n* = 4)	Ery, Clin, Tet	4 (100)
E. durans (*n* = 2)	Ery, Clin	1 (50)
	Ery, Clin, Virg	1 (50)
E. faecalis (*n* = 6)	Tet	1 (17)
	Ery, Clin, Tet	4 (66)
	Ery, Clin, Tet, Virg	1 (17)
E. faecium (*n* = 1)	Ery, Clin, Tet, Virg	1 (100)
E. hirae (*n* = 14)	Ery, Clin	1 (7)
	Ery, Clin, Tet	9 (64)
	Ery, Clin, Tet, Virg	4 (29)
Other *Enterococcus* (*n* = 11)	Ery, Clin, Tet	9 (82)
	Ery, Clin, Tet, Virg	2 (18)
Staphylococcus aureus (*n* = 1)	Ery, Clin, Tet	1 (100)
Coagulase-negative staphylococci (*n* = 42)	Ery, Tet	1 (2)
	Ery, Clin, Tet	8 (19)
	Ery, Clin, Virg	6 (14)
	Ery, Virg, Tet	1 (2)
	Ery, Clin, Tet, Virg	26 (62)
Viridans group streptococci (*n* = 43)	Tet	2 (5)
	Ery, Clin	1 (2)
	Ery, Tet	2 (5)
	Ery, Clin, Tet	35 (81)
	Ery, Clin, Tet, Virg	3 (7)

Abbreviations: Clin, clindamycin; Ery, erythromycin; Tet, tetracycline; Virg, virginiamycin.

Source: Chapin et al. (2005). *Environmental Health Perspectives,* 113(2), 137–142.

Results: Water Sampling

- 200 presumptive *Enterococcus* spp.
- Mean concentrations of drug-resistant *Enterococcus* spp. were
  - 10^2 CFUs/100mL in surface water
  - 10 CFUs/100mL in ground water
- Ground and surface water isolates downstream of the CAFO displayed patterns of antibiotic resistance similar to those observed in the airborne isolates

Conclusions

- High levels of multi-drug-resistant bacteria are present in CAFO air and in surface and ground waters downstream
- CAFO workers and growers are at high risk of exposure to airborne isolates
- Neighbors could be exposed to both airborne and waterborne resistant bacteria through inhalation or ingestion
- Air and water contaminated by swine CAFOs may serve as exposure pathways for the transfer of resistant bacteria from swine to humans

Climate Change

- Industrial agriculture system produces greenhouse gases (United Nations 2005 Millennium Ecosystem Assessment Synthesis Report)
- Livestock sector is a major player in climate change, responsible for 18 percent of greenhouse gas emissions

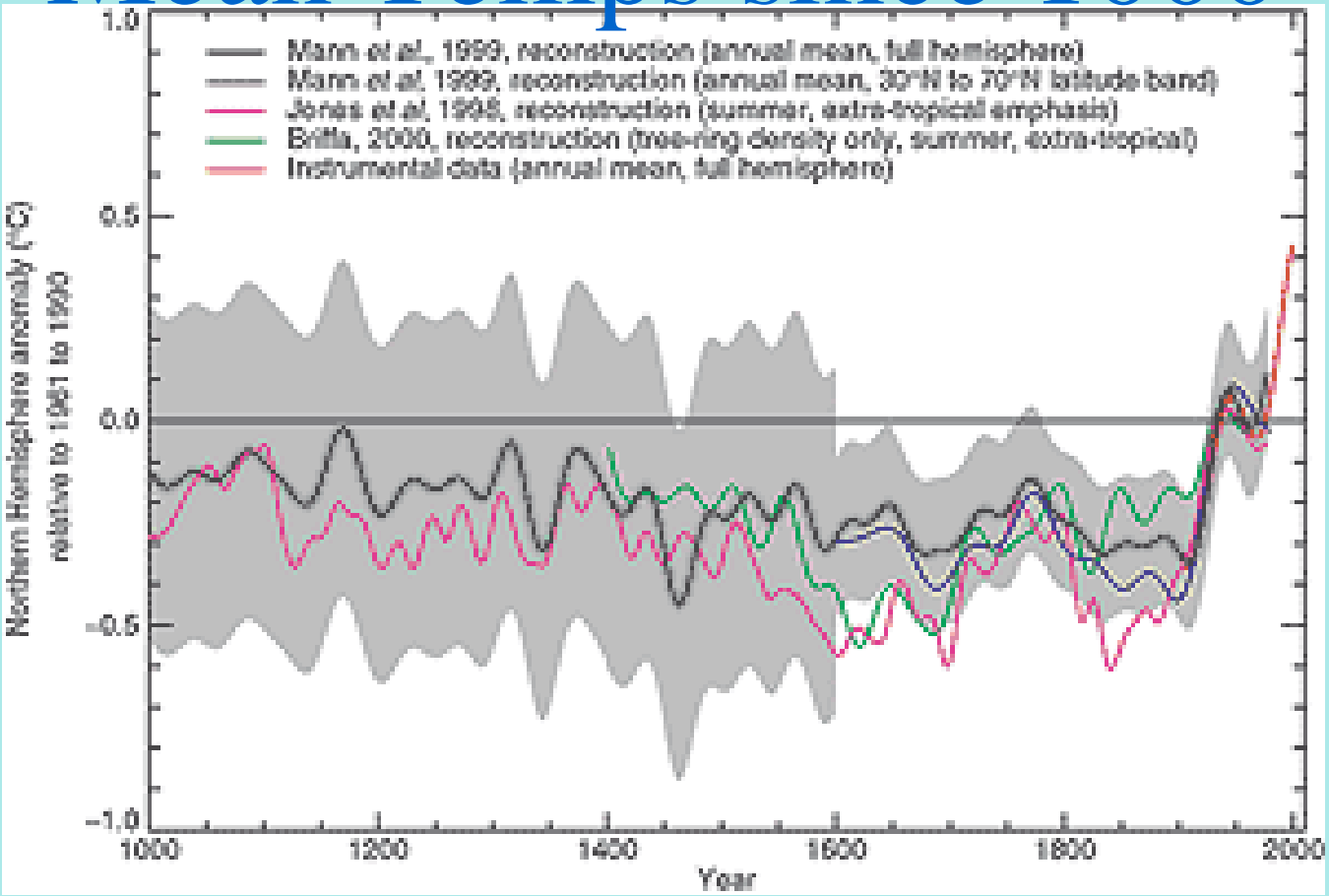
  measured in CO_2 equivalents

  (FAO Report, *Livestock's long shadow—Environmental issues and options)*

Climate Change

"Tomorrow's [Today's] Weather"

Mean Temps since 1000



Intergovernmental Panel on Climate Change (IPCC) 4th Report 2007

- Warming "Unequivocal"
- Human-caused
- 3.5-8° F rise by 2100
- 1°F warming unavoidable

- US contribution
  - 5% world population
  - 25% greenhouse gas emissions

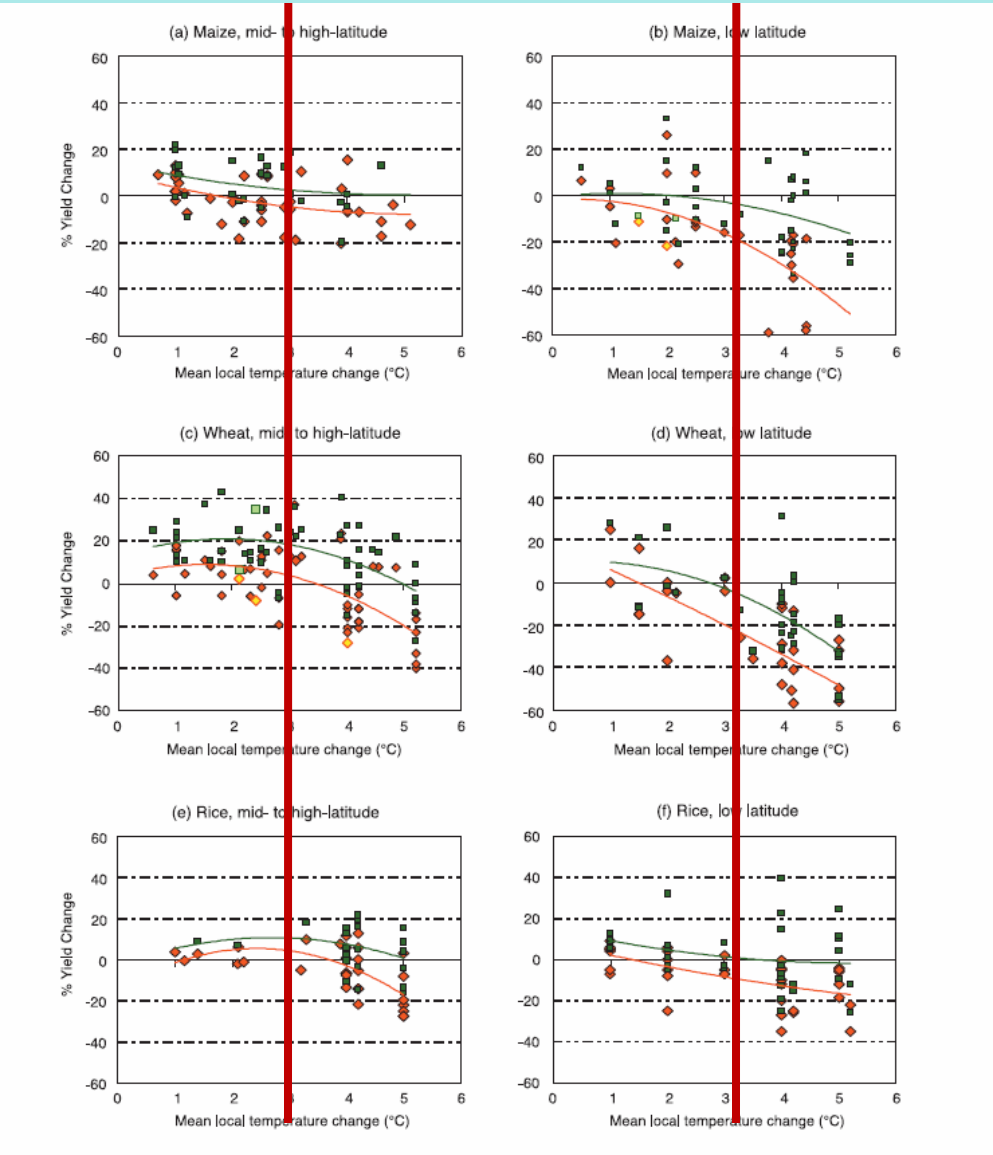
Effects on agriculture

Mid-to-High Latitude Low Latitude

Maize

Wheat

Rice

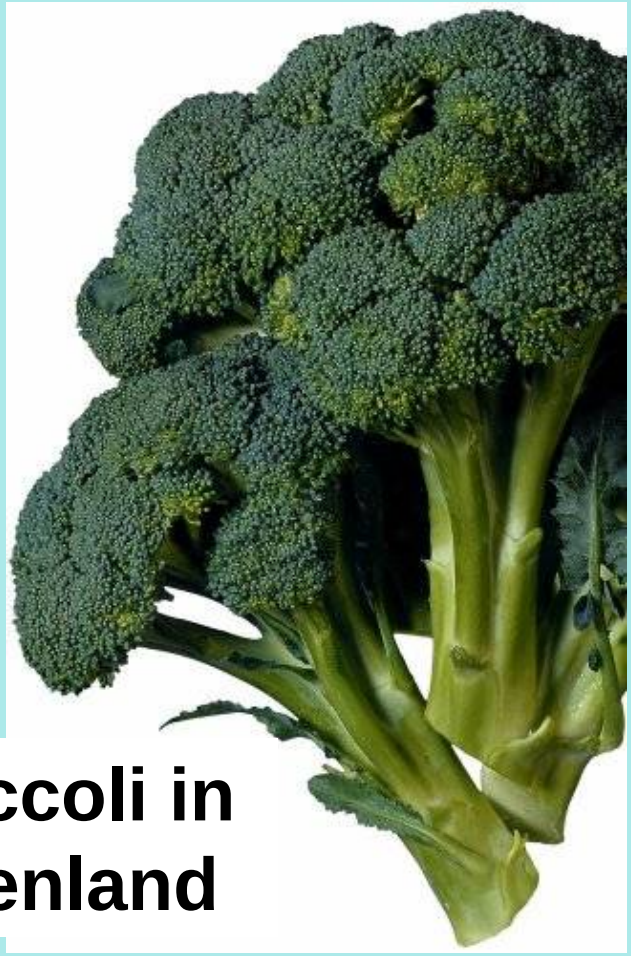


- 1-3º C
  - Some higher latitudes: neutral or slight benefit
  - Lower latitudes: detrimental
- > 3º C
  - Detrimental in all latitudes

IPCC 2007

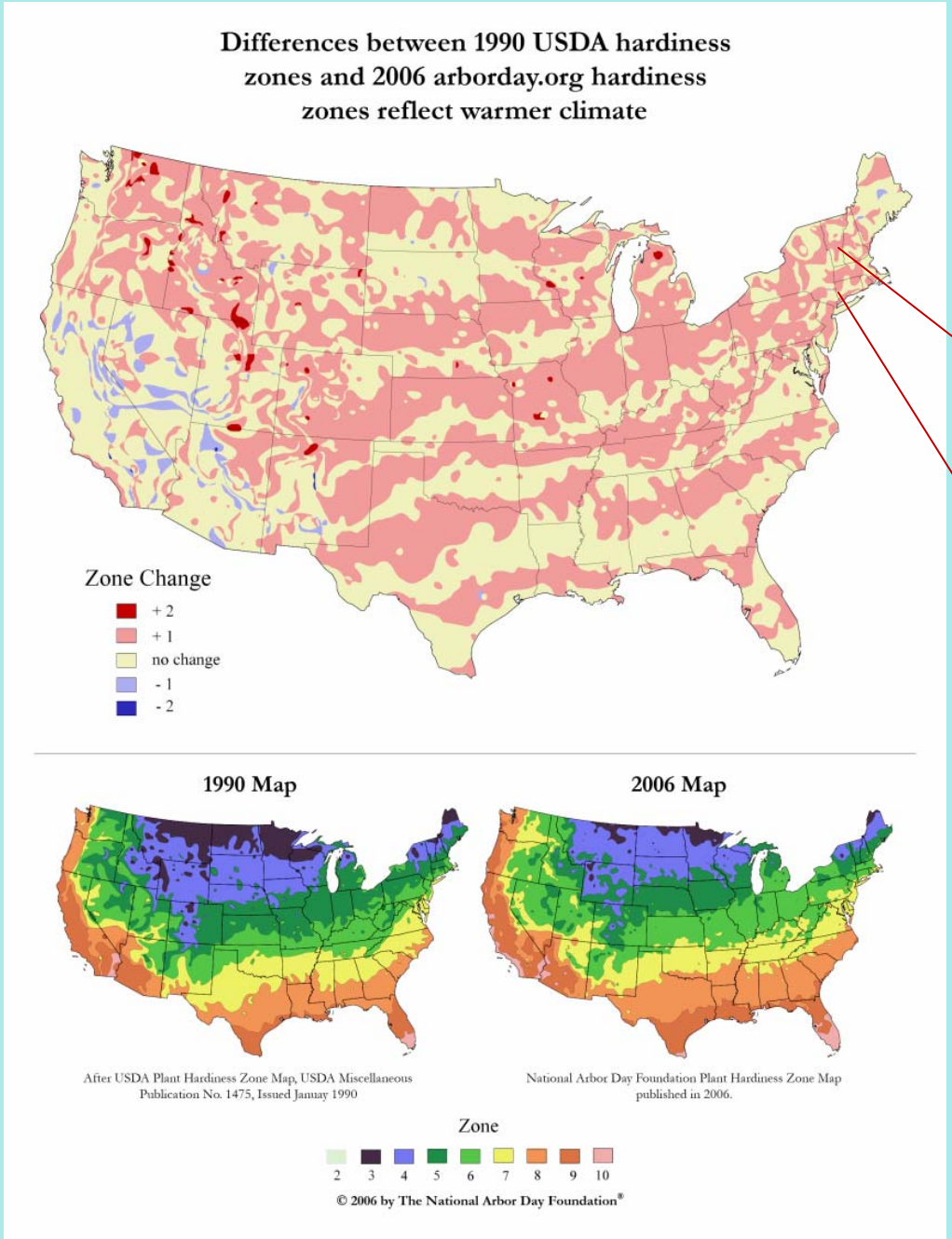
Already Happening

- Earlier spring
  - leaves, bird migration, egg laying
- Poleward/upward shifts in species geographic ranges
- Extreme weather, drought
- Pests, invasive species
- Biodiversity loss



Broccoli in Greenland

New Plant Hardiness Zones

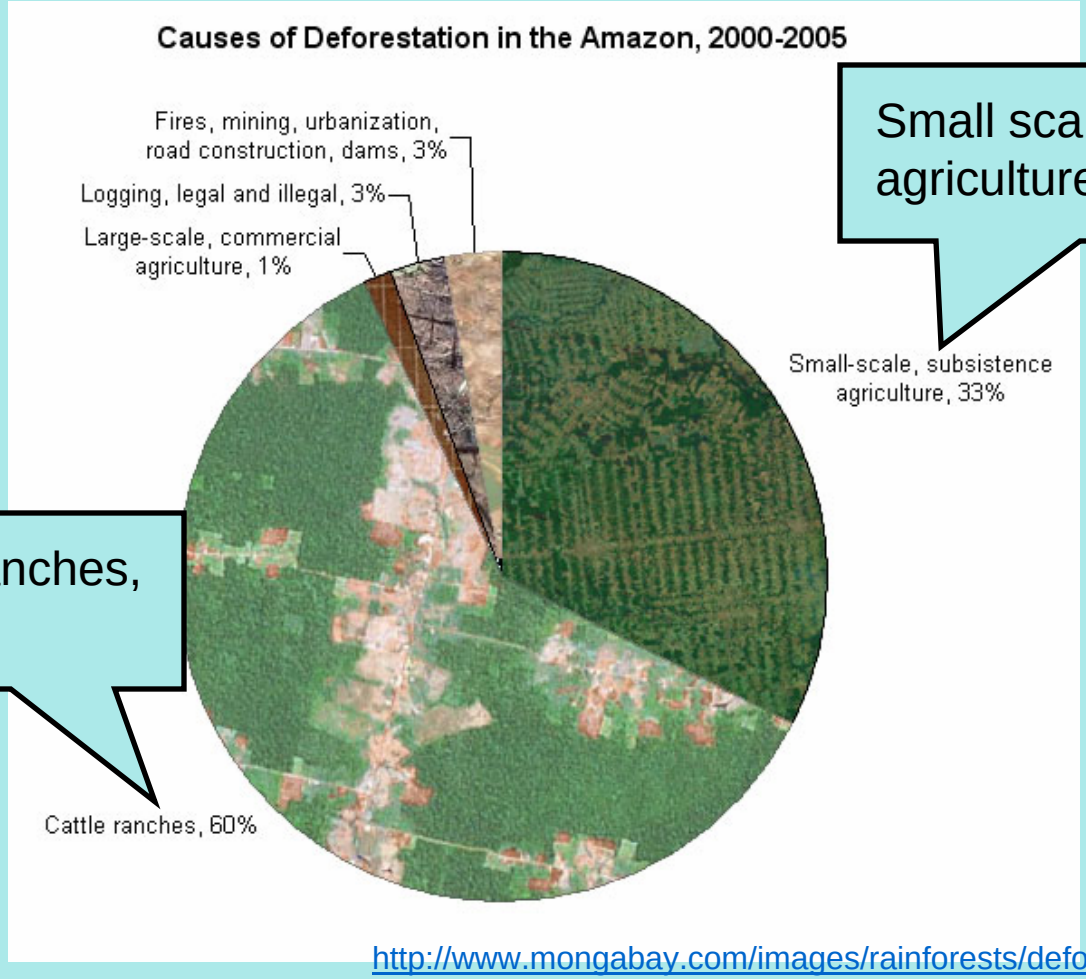


IPCC 2007

"global increases in carbon dioxide (CO_2) concentration are due ***primarily*** to ***fossil fuel use*** and ***land use*** change, while those of methane (CH4) and nitrous oxide (N_2O) are ***primarily*** due to ***agriculture***."

(emphases added)

Causes of Deforestation in the Amazon, 2000-2005



Small scale, subsistence agriculture, 33%

Cattle ranches, 60%

http://www.mongabay.com/images/rainforests/deforestation-in-the-amazon.jpg based on inpe data. Accessed 9-6-07

Pew Center on Global Climate Change 2006

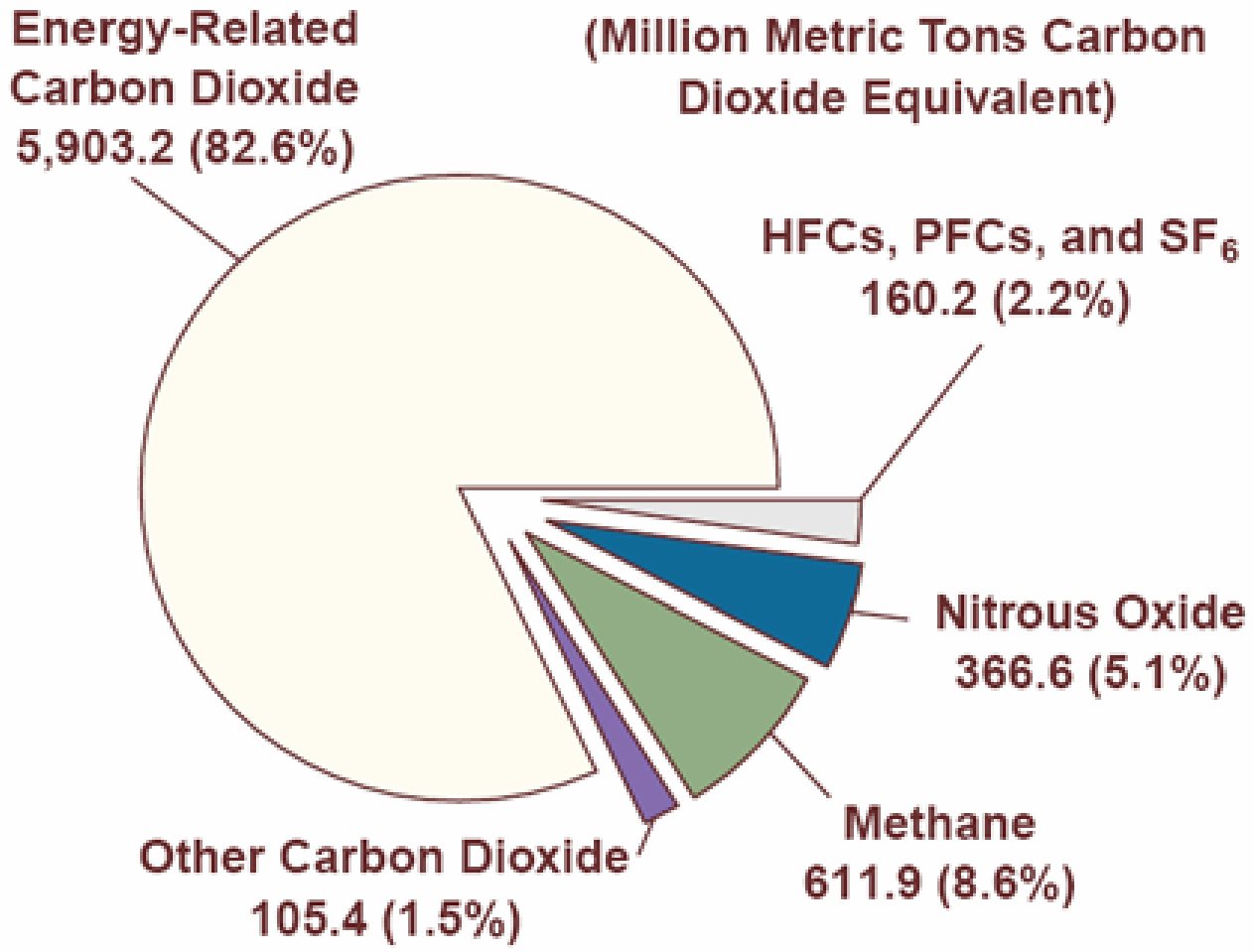
- ***1/3*** anthropogenic warming associated with greenhouse gases from worldwide ***agriculture*** and ***land use*** change

- ***8%*** in U.S.

U.N. F.A.O. 2006
"Livestock's Long Shadow"

- Livestock production: 18% world anthropogenic greenhouse gas emissions (CO2 equivalents)
- More than transportation's contribution

Figure ES1. U.S. Greenhouse Gas Emissions by Gas, 2005



Source: Tables ES2 and ES3.

Methane

- 21x "Global Warming Potential" of CO_2
- Enteric fermentation causes 71% US ag emissions (EPA estimate)
  - Quality of feed / digestibility of grasses
- Animal manure cesspits
  - Vs. pasture
- Rice paddies

Nitrous Oxide

- 286X global warming potential of CO_2, stays in atmosphere 114 yrs
- Nitrogen-based fertilizers a top source
- 51% US nitrogen is used for fertilizers for animal feed/pasture
  - Role of corn

Carbon Dioxide

- Energy
  - Food processing, transportation, cooling, heating, light, storage, facility needs, etc.
- Manufacturing
  - Fossil-fuel based pesticides, fertilizers, packaging, food items, plastic bags, etc

"Sinks"

- Soil and plant life trap greenhouse gases
- Conservation programs beneficial
- Agricultural practices release these
  - Land clearing, tilling, poor soil mgt, others

Lower-Fossil Fuel Energy

- Crops, methane used to produce energy

Effects Variable, Interactive, Complex

- Local conditions, species, weather, energy efficiency, etc.
- The old “sustainable” isn’t enough
  - ‘No till’ vs. organic
  - ‘Buy local’ – hothouse emissions; ship emissions may be lower than truck
  - Vegetarian – extra dairy intake, air freight vegetables
  - CAFO vs. grass-fed animal production

Quantifying: Energy Used in Food Production

- US food production responsible for:
  - ***10.5%*** US energy use
  - ***17%*** US fossil fuel use

- Projected rise in food production energy use
  - ***0.9% / yr***

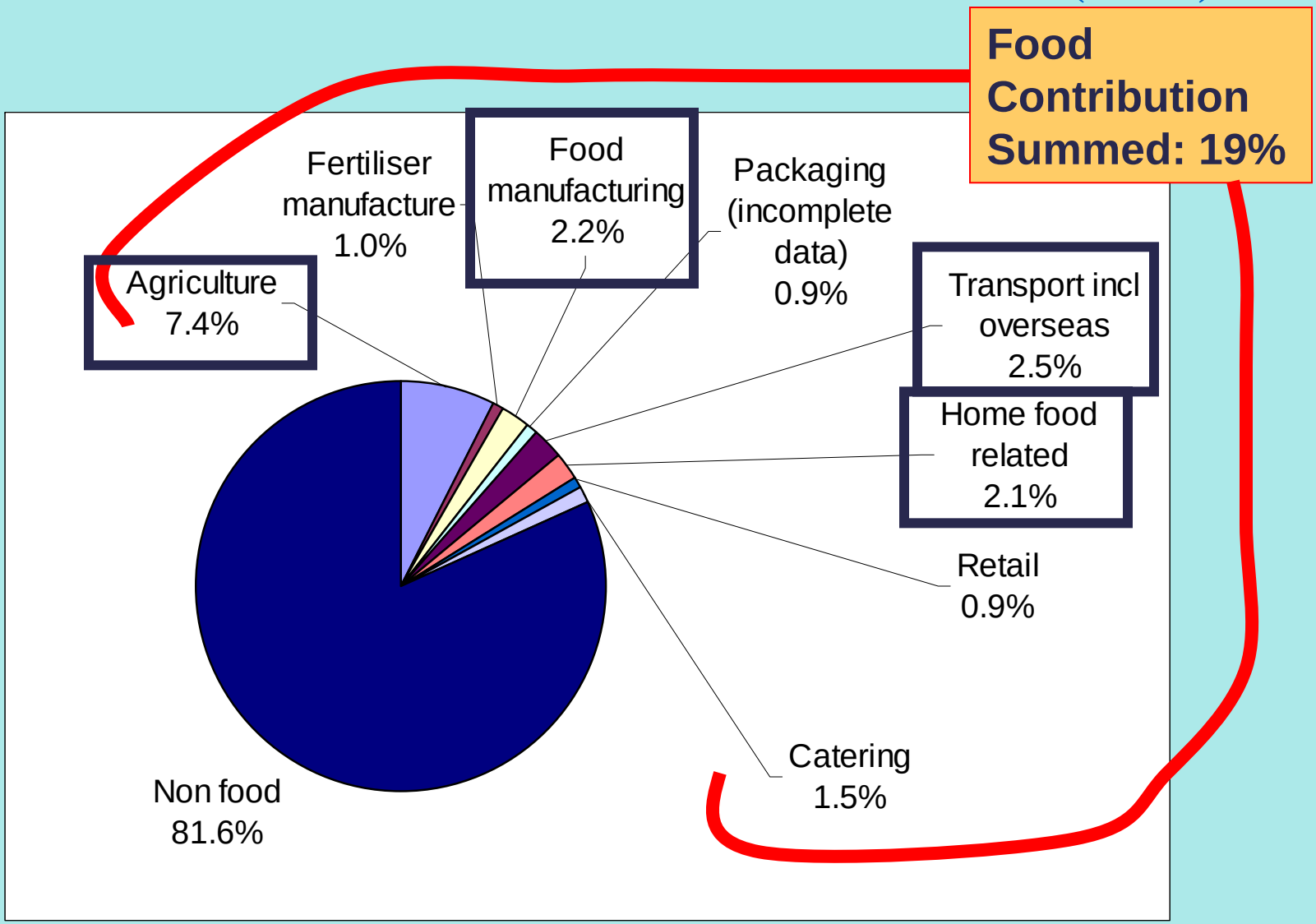
Quantifying Food Greenhouse Gases

(Much more going on in Europe!)

- UK – Food Climate Research Network
  - Around ***19%*** ('probable underestimate')
- EU *Environmental impact of products (EIPRO)* report (2006)
  - Food and drink: ***20-30%*** of environmental impacts of EU consumption

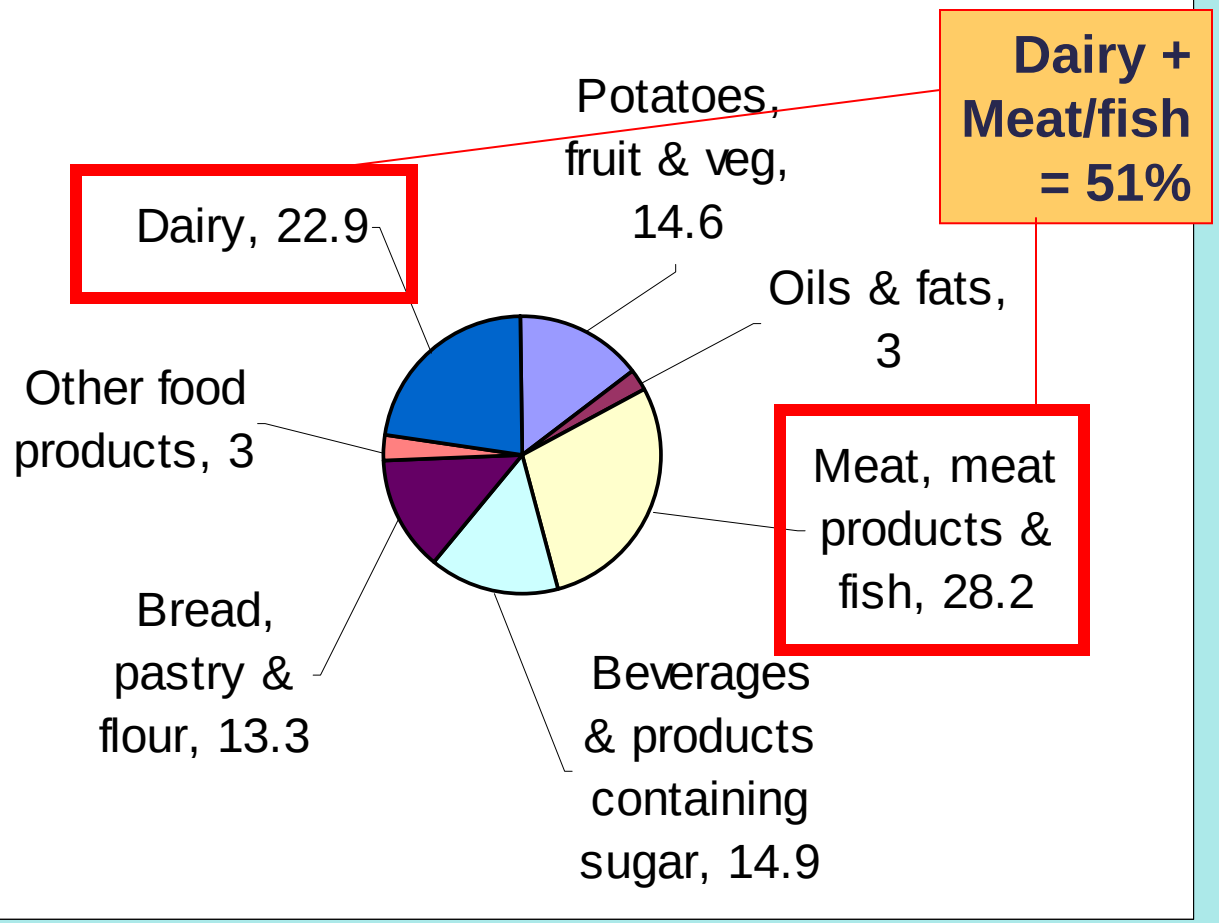
Environmental impact of products (EIPRO): Analysis of the life cycle environmental impacts related to the total final consumption of the EU25, European Science and Technology Observatory and Institute for Prospective Technological studies, full report, May 2006. http://ec.europa.eu/environment/ipp/identifying.htm

Food & Climate Research Network (UK)



Garnett T. 2007

Contribution of food groups to Dutch GHG emissions KG/CO2e



Klaas Jan Kramer, Henri C Moll, Sanderine Nonhebel, Harry C Wilting, Greenhouse gas emissions related to Dutch food consumption, *Energy Policy* 27 (1999) 203-216,. Slide: Garnett T

Individual Level

- Eat:
  - Less meat/dairy
  - More low-processing, seasonal, long shelf-life, local
  - Less packaging / bring own bag
  - Reduce refrigeration, freezing
  - Reduce trips to store
  - Less
- Problems include:
  - Hard to make and sustain
  - Food environment not supportive
  - Not always clear what to buy

Business Level

Bon Appetit – "Low Carbon Diet"

- Reducing beef by 25%
- All meat, poultry from North America
- Nearly all fruits/vegetables from North America
  - Seasonal local produce
  - Tropical fruits as "special occasion"
- Domestic bottled water, reducing plastic bottle waste
- Goal: reduce food waste by 25%, 3 years
- Auditing equipment energy efficiency
- Carbon point system to aid in calculating impact

“Climate Counts” (Stonyfield Farms)

- Climate scorecard for businesses
  - Identify & quantify emissions
  - Set goals & establish internal management
  - Achieve reductions
  - Encourage reductions by others
  - Support public policy
  - Reporting

Agricultural Industry Changes

- Attainable best management practices could cut emissions by 5-14% (Pew)
- Example: Soil management
  - Reduce tilling
  - Control erosion, cover crops
  - Add organic matter
  - Avoid overgrazing
  - Avoid excessive fertilizers
  - Avoid salinization

Government-Level

- Is individual and voluntary change enough?
  - Standards & labeling
  - Regulation of methods, energy efficiency
  - Institutional purchasing
  - $ for research
  - $ to stimulate enterprise / local markets
  - $ for communication campaigns
  - Food/ag policy integrated into climate change policy